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MATHÉMATIQUES

NOUVELLES ÉVALUATIONS DES SOMMES DE WEYL

Par I. VINOGRADOV, de l'Académie

§ 1. Adoptons les désignations suivantes:
n nombre entier constant $\geqslant 20$.
(α) distance de α à l'entier le plus proche; $\{\alpha\}$ partie fractionnaire du nombre α.
$A \ll B$ ou $B \gg A$ équivaut à $A = O(B)$.
$a_0, a_1, \ldots, a_n$ réels; Q et P entiers;

$$f(x) = a_0 x^n + \ldots + a_n; \quad S = \sum_{x=Q+1}^{Q+P} e^{2\pi i f(x)};$$

$$\nu = \frac{1}{n}; \quad a_0 = \frac{a}{q} + \theta q^{-2+\nu^2}; \quad (a, q) = 1; \quad q > 0; \quad |\theta| < 1;$$

$$p = q^{\nu}; \quad \sigma = (1-\nu)^{k-1}; \quad 0 < P \ll P_1; \quad \varepsilon = \frac{\delta n^2}{2}.$$

Dans les raisonnements à suivre nous admettons q assez grand. Nous conduirons notre démonstration en partant de deux suppositions principales:

1. $k = [2n \lg n + 2n]$; $P_1 = q^{2\nu - 2\nu^2 + 2\nu^3}$; $Y = [q^{\nu - 2\nu^2}]$; $\delta = \frac{\nu^3}{3k}$.

2. $k = [3n \lg n + 3n]$; $P_1 = q^{\frac{2}{2n-1}}$; $Y = \left[q^{\frac{\nu^2}{2}}\right]$; $\delta = \frac{\nu^4}{5k}$.

Soit ensuite p_k désignant l'entier positif

$$q_s = \left[2n^{\frac{1}{1-\nu}} p_s^{\frac{\nu}{1-\nu}} + 1\right]; \quad p_{s-1} = q_s p_s; \quad s = 2, \ldots, k.$$

Le nombre p_k peut être choisi de telle façon que l'on ait $p \ll p_1 \ll p$.

§ 2. En posant $A_s = \left| \sum_{u_s=0}^{p_s-1} e^{2\pi i f(x+\xi_2 p_2 y + \ldots + \xi_s p_s y + u_s y)} \right|^{2n(k+1-s)}$;

nous avons

$$S = \frac{1}{p_1 Y} \sum_{x} \sum_{y=1}^{Y} \sum_{u_1=0}^{p_1-1} e^{2\pi i f(x+u_1 y)} + O(pY) \ll$$

$$\ll \frac{1}{pY} (PY)^{1-\frac{1}{2nk}} \left(\sum_{x} \sum_{y} A_1 \right)^{\frac{1}{2nk}} + pY. \qquad (1)$$

$$A_1 \ll \left| \sum_{u_1} e^{2\pi i f(x+u_1 y)} \right|^{2n} q_2^{2n(k-1)-1} \sum_{\xi_2=0}^{q_2-1} A_2,$$

. . . . . .

$$A_{k-1} \ll \left| \sum_{u_{k-1}} e^{2\pi i f(x+\xi_2 p_2 y + \ldots + \xi_{k-1} p_{k-1} y + u_{k-1} y)} \right|^{2n} q_k^{2n-1} \sum_{\xi_k=0}^{q_k-1} A_k.$$

De là nous nous assurons que A_1 se laisse représenter par une somme

$$(q_2^{k-1} q_3^{k-2} \dots q_k)^{2n} \ll p^{2nk} (p_1 \dots p_k)^{-2n} \tag{2}$$

de termes de l'aspect de $(B)^2$, où après le remplacement des variables de sommation chaque B sera représenté sous la forme de (x_0 ne dépendant pas de t):

$$B = \prod_{t=1}^{k} S_t^n; \quad S_t = \sum_{v_t=-r_t}^{p_t-r_t-1} e^{2\pi i f(x_0+v_t y)}; \quad 0 < r_t < p_t.$$

Nous fractionnerons chaque somme S_t en $\ll p^\varepsilon$ sommes de l'aspect de

$$\sum_{v_{ts}} e^{2\pi i f(x_0+v_{ts}y)}$$

à longueur d'intervalle de sommation $\leqslant p_t p^{-\varepsilon}$. Alors S_t^n se fractionnera en $\ll p^{\varepsilon n}$ sommes et B se fractionnera en $\ll p^{\varepsilon nk}$ sommes C de l'aspect de

$$C = \prod_{t=1}^{k} e^{2\pi i [f(x_0+v_{t1}) + \dots + f(x_0+v_{tn})]}.$$

En même temps nous aurons

$$|B|^2 \ll p^{\varepsilon nk} \sum\nolimits_1 |C|^2. \tag{3}$$

Adoptant la formule de Taylor nous avons

$$C = \sum_{2}^{k} e^{2\pi i (a_0 U_n y^n + a_1 U_{n-1} y^n + \dots + a_n)};$$

$$U_r = \sum_{t=1}^{k} V_{tr}; \quad V_{tr} = \varphi_{t1}^r + \dots + \varphi_{tn}^r;$$

la sommation s'étendant dans cette expression pour C à tous les systèmes possibles de valeurs de

$$\varphi_{11}, \dots, \varphi_{1n}; \dots; \varphi_{k,1}, \dots, \varphi_{kn}.$$

Si maintenant nous rejetons les termes $|C|^2$ de la sommation dans lesquels ne fût-ce que pour une valeur de t une différence au moins de l'aspest de $\varphi_{tg} - \varphi_{th}$ est moindre que $p_t p^{-\delta}$, on verra aisément que l'évaluation de la somme S ne sera pas changée de plus que de la valeur de

$$\ll P p^{-\frac{\delta}{2kn}} \tag{4}$$

tandis que dans l'évaluation à obtenir pour A_1 il restera

$$\ll p^{2kn} (p_1 \dots p_k)^{-2n} p^{2\varepsilon nk}$$

termes $|C|^2$ de la sommation tels que pour tous $t = 1, \dots, k$ nous ayons pour des $\varphi_{t1}, \dots, \varphi_{tn}$ choisis arbitrairement:

$$\left\| \begin{matrix} \varphi_{t1}^{n-1}, \dots, \varphi_{tn}^{n-1} \\ \dots\dots\dots \\ \varphi_{t1}, \dots, \varphi_{tn} \\ 1, \dots, 1 \end{matrix} \right\| \gg p_t^{\frac{n(n-1)}{2}} p^{-\frac{\delta n^2}{2}(1-\nu)}. \tag{5}$$

§ 3. Considérons maintenant l'une quelconque d'entre les valeurs restantes de C. Désignons pour correspondre à chaque $r = 1, \dots, n$ un intervalle de longueur

$$p_t^{r-1}$$

et voyons quel sera le nombre N_t des systèmes de valeurs de $\varphi_{t1}, \dots, \varphi_{tn}$, pour lesquels tous les V_{tr}; $r = 1, \dots, n$ viendront se placer en même temps dans les intervalles en question.

Si

$$\eta_1, \ldots, \eta_n;\ \eta_1 + s_1, \ldots, \eta_n + s_n$$

sont deux pareils systèmes de valeur de $\varphi_{t1}, \ldots, \varphi_{tn}$, il faut que l'on ait

$$(\eta_1 + s_1)^n - \eta_1^n + \ldots + (\eta_n - s_n)^n - \eta_n^n = O\left(p_t^{n-1}\right)$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$(\eta_1 + s_1)^2 - \eta_1^2 + \ldots + (\eta_n + s_n)^2 - \eta_n^2 = O(p_t)$$

$$\eta_1 + s_1 - \eta_1 + \ldots + (\eta_n + s_n) - \eta_n = O(1),$$

d'où en vertu de (5) on trouvera aisément

$$s_i \ll p^{\frac{\delta n^2}{2}};\ N_t \ll p^{\frac{\delta n^3}{2}}.$$

Nous désignerons ensuite pour correspondre à chaque $r = 1, \ldots, n$ un intervalle de longueur

$$p_t^{r(1-\nu)}.$$

Alors, le nombre N_t des systèmes de valeurs de $\varphi_{t1}, \ldots, \varphi_{tn}$ pour lesquels tous les V_{tr}; $r = 1, \ldots, n$ viendront se placer en même temps dans ces nouveaux intervalles, sera de

$$N_t \ll p_t^{\frac{n-1}{2}} p^{\frac{\delta n^3}{2}}. \qquad (6)$$

§ 4. Procédons maintenant à l'évaluation pour des entiers W_r; $r = 1, \ldots, n$ donnés du nombre T des solutions du système

$$U_r = W_r;\ r = 1, \ldots, n.$$

Toutes les valeurs que pourra prendre la somme

$$V_{t+1,r} + \ldots + V_{kr}$$

sont évidemment comprises dans un intervalle parfaitement défini de longueur $\leqslant p_t^{r(1-\nu)}$.

Nous concluons de là que tous les V_{1r}; $r = 1, \ldots, n$ sont compris dans des intervalles parfaitement définis de longueurs $p_1^{r(1-\nu)}$; ensuite pour chaque système donné des nombres V_{1r} les nombres V_{2r} sont compris dans des intervalles parfaitement déterminés de longueurs $p_2^{r(1-\nu)}$ et ainsi de suite; enfin, pour chaque ensemble donné de systèmes de nombres $V_{1r}, \ldots, V_{k-2,r}$; $r = 1, \ldots, n$ les $V_{k-1,r}$ sont compris dans des intervalles parfaitement déterminés de longueurs $p_{k-1}^{r(1-\nu)}$.

Résumant ce qui a été démontré et observant que le nombre des systèmes de valeurs de V_{kr}; $r = 1, \ldots, n$ sera

$$\ll p_k^n,$$

nous aurons, en vertu de (6),

$$T \ll (p_1 \ldots p_{k-1})^{\frac{n-1}{2}} p_k^n p^{\frac{\delta n^3 k}{2}}.$$

§ 5. Nous avons:

$$\sum_y |C|^2 = \sum_y \sum_2 \sum_2' e^{2\pi i [a_0 (u_n - u_n')y^n + \ldots + \alpha_{n-1}(u_1 - u_1')y]} \ll$$

$$\ll (p_1 \ldots p_k)^n p^{-\varepsilon n k} (p_1 \ldots p_{k-1})^{\frac{n-1}{2}} p_k^n p^{\frac{\delta n^3 k}{2}} \Omega;$$

$$\Omega = \sum_{z_n \gg -p^n}^{\ll p^n} \ldots \sum_{z_1 \gg -p}^{\ll p} \left| \sum_y e^{2\pi i [a_0 z_n y^n + \ldots + \alpha_{n-1} z_1 y]} \right| \ll$$

$$\ll p^{\frac{n(n-1)}{2}} \sqrt{p^n \sum_y \sum_{y_1} \min\left(p^n, \frac{1}{[a_0(y^n - y_1^n)]}\right)} \ll p^{\frac{n(n+1)}{2}} Y^{\frac{1}{2}}.$$

Par conséquent et en vertu de (1), (2), (3) et (4), nous obtiendrons:

$$S \ll Pq^{\frac{1+\nu}{4k}\sigma+\frac{\delta n}{2}} Y^{-\frac{1}{4nk}} + Pq^{-\frac{\delta\nu^2}{2k}} + Yq^{\nu}.$$

§ 6. Conformément aux suppositions 1 et 2 du § 1 nous obtenons de ce qui précède le théorème:

Théorème. Soit n un entier $\geqslant 20$;

$$a_0, \ldots, a_n \text{ réels; } Q \text{ et } P \text{ entiers; } 0 < P \ll P_1;$$

$$f(x) = a_0x^n + \ldots + a_n; \quad S = \sum_{x=Q+1}^{Q+P} e^{2\pi i f(x)}; \quad \nu = \frac{1}{n};$$

$$a_0 = \frac{a}{q} + \theta q^{-2+\nu^2}; \quad (a,q) = 1; \quad q > 0; \quad |\theta| \leqslant 1.$$

Alors nous avons

$$S \leqslant cP_1q^{-\rho},$$

où c est une constante, dépendant de n seulement et

$$\rho = \frac{\nu^7}{24(\lg n + 1)^4}, \text{ si } P_1 = q^{2\nu-2\nu^2+\nu^3};$$

$$\rho = \frac{\nu^8}{90(\lg n + 1)^2}, \text{ si } P_1 = q^{\frac{2}{2n-1}}.$$

Corollaire. Soient Q et P des entiers,

$$A \gg 1; \quad P \gg A^{2\nu}$$

et dans l'intervalle $Q \leqslant x \leqslant Q + P$ la fonction réelle $f(x)$ satisfaisant aux conditions

$$\frac{1}{A} \ll f^{(n)}(x) \ll \frac{1}{A}; \quad f^{(n+1)}(x) \ll \frac{1}{A^2}.$$

Alors

$$\sum_{x=Q+1}^{Q+P} e^{2\pi i f(x)} \ll PA^{-\rho}; \quad \rho = \frac{\nu^7}{24(\lg n + 1)^2}.$$

Exemple 1. L'expression asymptotique pour le nombre des fractions

$$\{f(x)\}; \quad x = 1, \ldots, P'$$

situées dans un intervalle donné avec la condition $P' \gg P_1$ pour les cas du théorème et $P' \gg A^{2\nu}$ pour le corollaire de notre théorème, s'obtient avec une exactitude à des grandeurs de l'ordre de: $P'q^{-\rho}$ près pour les cas du théorème et de $P'A^{-\rho}$ près pour le corollaire du théorème.

Exemple 2. L'expression asymptotique de Hardy-Littlewood pour le nombre des représentations d'un entier $N \geqslant N_0(n)$ sous la forme de

$$N = x_1^n + \ldots + x_r^n$$

est valable pour tous

$$r \geqslant 183\, n^9 (\lg n + 1)^2$$

À examiner de plus près le déterminant du § 2 dans les numérateurs des expressions pour ρ, ρ_1, ρ_2, l'exposant de la puissance de ν diminue partout d'une unité; par exemple on a

$$\rho = \frac{\nu^6}{24(\lg n + 1)^2}.$$

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MATHEMATIK

ÜBER EINIGE SÄTZE DER GRUPPENTHEORIE

VON S. A. TCHOUNIKHIN

(*Vorgelegt von I. M. Vinogradow, Mitglied der Akademie, d. 2. VIII. 1935*)

1. Sei $\mathfrak{H}$ eine Untergruppe der endlichen Gruppe $\mathfrak{G}$, und sei $\mathfrak{K}$ die Kommutatorgruppe von $\mathfrak{H}$. Wie ich in meiner Arbeit «Une généralisation des théorèmes de G. Frobenius et W. Turkin» (1) gezeigt habe, erhalten wir eine Darstellung der Gruppe $\mathfrak{G}$ durch die Faktorgruppe $\frac{\mathfrak{H}}{\mathfrak{K}}$, in welcher dem Elemente A der Gruppe $\mathfrak{G}$ ein neues Element $|A|$ der Gruppe $\frac{\mathfrak{H}}{\mathfrak{K}}$ entspricht:

$$|A| = A^{\alpha_1} D_2 A^{\alpha_2} D_2^{-1} D_3 A^{\alpha_3} D_3^{-1}, \ldots, D_s A^{\alpha_s} D_s^{-1} \mathfrak{K}, \tag{1}$$

wenn die Zerlegung der Gruppe $\mathfrak{G}$ in folgender Form geschrieben ist:

$$\mathfrak{G} = \mathfrak{H} + \mathfrak{H}A + \mathfrak{H}A^2 + \ldots + \mathfrak{H}A^{\alpha_1 - 1} + \mathfrak{H}D_2 + \mathfrak{H}D_2 A + \ldots + \mathfrak{H}D_2 A^{\alpha_2 - 1} + \\ + \ldots + \mathfrak{H}D_s + \mathfrak{H}D_s A + \ldots + \mathfrak{H}D_s A^{\alpha_s - 1}.$$

Mit Hilfe dieser Formel (1) beweise ich den folgenden Satz.

Satz 1. *Sei $\mathfrak{H}$ eine Untergruppe von Index k der Gruppe $\mathfrak{G}$ und sei $\mathfrak{K}$ die Kommutatorgruppe von $\mathfrak{H}$. Sei in $\mathfrak{H}$, aber nicht in $\mathfrak{K}$, ein Element A von Primzahlpotenzordnung p^ω enthalten (k und p sind teilerfremd), für welches keine Potenz A^λ in $\mathfrak{K}$ auftritt. Wenn alle Elemente von $\mathfrak{H}$, die mit A in $\mathfrak{G}$ konjugiert sind, dem System $\mathfrak{K}A$ angehören, so ist die Gruppe $\mathfrak{G}$ nicht einfach.*

2. Hilfssatz. *Sei $\mathfrak{G}$ eine Gruppe der Ordnung $p_1^{\alpha_1}, p_2^{\alpha_2}, \ldots, p_n^{\alpha_n}$, wo $p_1 < p_2 < \ldots < p_n$, und sei $\mathfrak{P}$ eine von ihren Sylowschen Untergruppen der Ordnung $p_1^{\alpha_1}$. Für jedes Element X der Gruppe $\mathfrak{G}$ ist die Gleichung $X^{-1} A^\alpha X = A^\beta$, $\alpha \not\equiv \beta \pmod{p_1^m}$, unmöglich, wenn A ein Element von der Ordnung p_1^m des Zentrums der Gruppe $\mathfrak{P}$ ist.*

Aus der Formel (1) und unserem Hilfssatze folgt.

Satz 2. *Sei $\mathfrak{G}$ eine einfache Gruppe der Ordnung $p_1^{\alpha_1}, p_2^{\alpha_2}, \ldots, p_n^{\alpha_n}$, wo $p_1 < p_2 < \ldots < p_n$, und sei $\mathfrak{P}$ eine von ihren Sylowschen Untergruppen der Ordnung $p_1^{\alpha_1}$. Dann enthält das Zentrum der Gruppe $\mathfrak{P}$ nur die Elemente, deren Ordnungen $\sqrt{p_1^{\alpha_1}}$ nicht übertreffen.*

Dieser Satz (und auch der Hilfssatz) gilt nicht nur für den Fall, wenn p_1 die kleinste Primzahl ist, die in die Ordnung der Gruppe $\mathfrak{G}$ aufgeht, sondern auch, wenn $p_1 - 1$ zur Ordnung der Gruppe $\mathfrak{G}$ teilerfremd ist.

3. Aus der Formel (1) folgt auch:

Satz 3. *Ist $\mathfrak{H}$, eine Untergruppe der Gruppe $\mathfrak{G}$, mit ihrem Normalisator in $\mathfrak{G}$ identisch und sei in $\mathfrak{H}$, aber nicht in der Kommutatorgruppe von $\mathfrak{H}$, ein Element A enthalten, für welches keine Potenz $A^\lambda \neq 1$ in andere mit $\mathfrak{H}$ konjugierte Untergruppe von $\mathfrak{G}$ auftritt, so ist die Gruppe $\mathfrak{G}$ nicht einfach.*

Dieser Satz ist eine Vertiefung des bekannten Satzes von G. Frobenius (2) für den Fall, wenn $\mathfrak{H}$ von ihrer Kommutatorgruppe verschieden ist; aber unserer Beweis ist von der Theorie der Gruppencharaktere unabhängig.

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ASTRONOMY

THE PHOTOGRAPHIC MERIDIAN CIRCLE

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The success of the application of photography to zonal observations points to the necessity of introducing the photographic method into absolute astrometry. Good results have already been obtained in Greenwich and Washington in the application of the photographic method to the observations of latitude with the aid of a floating photographic zenith telescope. Very little attention has been paid, though, to the method of photographic recording of the transit of stars on the transit instrument.

The scheme I am proposing solves the problem of photographic observations of faint stars with a transit circle and makes away to a considerable extent with the errors due to the mounting of the instrument and the irregularities of the pivots of the horizontal axis*.

The proposed design of the photographic transit or meridian instrument provides for two objectives, mounted on the ends of the horizontal axis, for the observation of mires, i. e. artificial stars situated in the direction of east and west. The images of the mires are directed towards the focal plane of the main objective by means of two prisms securely fastened to the central part of the cube.

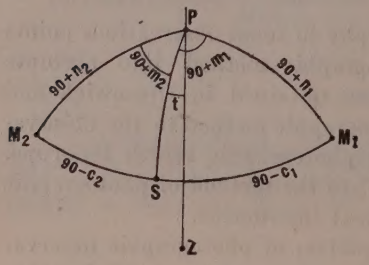
We shall see the image of the eastern and western mires simultaneously with seeing the stars. With the aid of a micrometer we can measure the distance of each mire from the central thread of the instrument, and thus we can reduce the observation of the transit of stars through the central thread to such a position of the instrument when the central thread passes through one of the mires. In the absence of a micrometer this can be achieved by adjusting the screws of the instrument by altitude and azimuth.

In the case of photographic observations, the micrometer may be replaced by a movable plate-holder automatically moving with different speed in conformity to the declination of the star. Thus it becomes possible to

* This idea has been first suggested by me at a meeting of the Astronomical Society in 1916.

expose a star for several minutes and consequently to observe faint stars (up to 11.0 magnitude) in dependence on the size and the aperture of the main objective. The mires will leave trails upon the movable plate. By interrupting the light from the mires with the aid of a contact clock, we can get a sort of chronograph tape upon the plate. By dropping a perpendicular from the star to the line of the trails of mires, we can measure «the time of the transit of the star through the mire».

In observing star declinations, the cross of the threads immediately connected with the ocular part of the instrument will be printed upon the photographic plate. The reading of the vertical circle should be made photographically with the aid of special photomicroscopes. The circle, a cast disc 50 cm in diameter, may be divided into spaces of 20′ (in all 1080 divisions). This number will do. A magnification of 8 diameters will ensure an accuracy of 0″.2. In view of the small number of divisions there is no need to strive for correct graduation. The individual error of each division may be readily determined, particularly if, in investigating the circle, we should employ the photographic method of reading. This would accelerate the process of observation to a considerable degree and, consequently, guarantee a greater constancy of temperature during the observation of the series, as compared to visual observations.



We will now proceed to the exposition of the theory of the transit instrument. Let the eastern mire M_1 (v. Fig.), have the following equatorial coordinates: the polar distance $PM_1=90+n_1$ and the hour angle (direction east) $SPM_1=90+m_1$. At the moment T_1, when the star in the field of vision is simultaneously with the mire upon the vertical thread, the arc M_1S will be equal to $90-c_1$, where c_1 is their collimation error relating to the setting of the first prism of the central portion of the instrument axis. Denoting the declination and the hour angle of star S by δ and t, we can write:

$$\sin c_1 = -\sin\delta \sin n_1 - \cos\delta \cos n_1 \cos(t + m_1). \qquad (1)$$

Assuming the quantities m_1, n_1, c_1, to be small, we can write the following equation for the determination of the hour angle of the star

$$t = -(m_1 + c_1 \sec\delta + n_1 \operatorname{tg}\delta). \qquad (2)$$

Assuming, on the other hand, that the hour angle is equal to the difference in sidereal time (T_1+u) and the right ascension of the star α, we can write the following fundamental equation for the determination of the right ascension of the star on the basis of the observations of the eastern mire:

$$\alpha = T_1 + u + m_1 + c_1 \sec\delta + n_1 \operatorname{tg}\delta. \qquad (3)$$

Likewise, denoting by $90°+n_2$ the polar distance of the western mire and by $90°+m_2$ (direction west) the hour angle of the mire and by $90°-c_2$ the arc SPM_2, we can write the following equation for the determination of the right ascension of the star on the basis of observations of the western mire

$$\alpha = T_2 + u - m_2 - c_2 \sec\delta - n_2 \operatorname{tg}\delta. \qquad (4)$$

When the horizontal axis of the instrument is turned through 180°, the collimation errors will change places. Thus, we can write two more formulae for the determination of the right ascension from observations of the eastern and western mires in the second position of the instrument.

$$\alpha = T_1' + u + m_1 + c_2 \sec\delta + n_1 \operatorname{tg}\delta; \qquad (5)$$
$$\alpha = T_2' + u - m_2 - c_1 \sec\delta - n_2 \operatorname{tg}\delta. \qquad (6)$$

From formulae (3), (4), (5), and (6) it follows that

$$T_2 - T_1 = T_2' - T_1' = (m_1 + m_2) + (c_1 + c_2)\sec\delta + (n_1 + n_2)\operatorname{tg}\delta, \qquad (7)$$

— a check on the constancy of the position of the mires and the collimation error during the observation.

Taking the mean of the observations of the eastern and western mires in the first and the second position of the instrument, we have:

$$\begin{aligned} \alpha &= \tfrac{1}{2}(T_1 + T_2) + u + m + c\sec\delta + n\operatorname{tg}\delta; \\ \alpha &= \tfrac{1}{2}(T_1' + T_2') + u + m - c\sec\delta + n\operatorname{tg}\delta, \end{aligned} \qquad (8)$$

where for brevity we put: $2m = m_1 - m_2$, $2n = n_1 - n_2$, $2c = c_1 - c_2$.

In this way the collimation, as in an ordinary transit circle, is eliminated or determined by turning the horizontal axis, while n is to be determined from polar stars.

The theory set forth above shows that the adjustment of the instrument and, consequently, the irregularities of the pivots do not affect the observations. In turning the instrument for the elimination or the determination of the collimation there is no need to assume the azimuth of the instrument to be invariable. The attention is fixed on the invariability of the position of the mires during the observations of the stars.

Should the work with the photographic transit circle prove successful, in fact, should we succeed in replacing visual observations by photographic ones, without detracting from the accuracy, we can take the next step and make the work of the meridian circle automatic, which will, no doubt, introduce a greater objectivity into the work of the instrument. It will at the same time shorten the process of observation, reduce the temperature effect of the observer upon the instrument, and, finally, save the energy of astronomers for a deeper discussion of the observations.

These are the fundamental principles of the powerful meridian circle that is being constructed by the Astronomical Institute in close collabora-

tion with the Abas-Tuman Astronomical Observatory. The meridian circle is to be mounted upon the plateau of Agobilli near Abas-Tuman, at a height of nearly 1700 m above sea-level. It will permit to carry on systematic observations of faint minor planets (up to 11.0 mag.) and to connect them reliably to the fundamental system of standard stars. This problem is of great scientific and practical significance and forms part of the international cooperation work on the construction of a fundamental system of stars.

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ON THE FLEXURAL CENTRE OF CLOSED THIN-WALLED SECTIONS

By L. S. LEIBENSON, Corresponding Member of the Academy

Van der Neut's method is generally used for the determination of the position of the flexural centre of closed thin-walled sections. But this method may sometimes give inexact results. Therefore, we suggest the following method. Let the thin-walled section be referred to the principal axes of the cross-section at its centroid. Let P_1 be a force that is parallel to the axis Ox and P_2 parallel to the axis Oy. Let I_1 be the moment of inertia of the cross-section about the axis Oy, I_2—about the axis Ox. Let

$$A = \frac{P_1}{I_1}, \qquad B = \frac{P_2}{I_2}. \tag{1'}$$

In the solution of the problem of flexure we follow Sen Venant [his solution is given by A. E. Love (1)]. We have

$$\left.\begin{aligned} u_1 &= -\tau yz + \frac{A}{E}\left[\frac{1}{2}\sigma(l-z)(x^2-y^2) + \frac{1}{2}lz^2 - \frac{1}{6}z^3\right], \\ v_1 &= \tau xz + \frac{A}{E}\sigma xy(l-z), \\ w_1 &= \tau\varphi_1 - \frac{A}{E}\left[x\left(lz - \frac{z^2}{2}\right) + \chi_1 + xy^2\right]; \end{aligned}\right\} \tag{1}$$

$$\left.\begin{aligned} X_z &= \mu\tau\left(\frac{\partial\varphi_1}{\partial x} - y\right) - \frac{A}{2(1+\sigma)}\left[\frac{\partial\chi_1}{\partial x} + \frac{\sigma x^2}{2} + \left(1 - \frac{\sigma}{2}\right)y^2\right], \\ Y_z &= \mu\tau\left(\frac{\partial\varphi_1}{\partial y} + x\right) - \frac{A}{2(1+\sigma)}\left[\frac{\partial\chi_1}{\partial y} + (2+\sigma)xy\right], \end{aligned}\right\} \tag{2}$$

where $\varphi_1(x, y)$ and $\chi_1(x, y)$ are determined from certain conditions given by A. Love. Let τ_s be the stress component in the direction of the tangent to the middle line of the section (Fig. 1); then we have:

$$\tau_s = X_z\cos(t, x) + Y_z\cos(t, y). \tag{3}$$

Taking the integral round a closed middle line, we have:

$$\oint \tau_s ds = \mu \oint \frac{\partial}{\partial s}\left(\tau\varphi_1 - \frac{A}{E}\chi_1\right)ds + \mu\tau \oint (xdy - ydx) - \\ - \frac{A}{2(1+\sigma)}\oint\left\{\left[\frac{\sigma x^2}{2} + \left(1 - \frac{\sigma}{2}\right)y^2\right]dx + (2+\sigma)xydy\right\}, \tag{4}$$

where σ is Poisson's ratio, μ is rigidity.

As u_1, v_1, w_1 are single-valued, we must have

$$\oint \frac{\partial}{\partial s}\left(\tau\varphi_1 - \frac{A}{E}\chi_1\right) ds = 0. \tag{5}$$

From Green's theorem we also have:

$$\oint \left\{\left[\frac{\sigma x^2}{2} + \left(1 - \frac{\sigma}{2}\right) y^2\right] dx + (2+\sigma)\, xy dy\right\} + 2\sigma \iint y dx dy, \tag{5'}$$

where the integral $\iint y dx dy$ is taken over the whole area limited by the middle line of the section. If the force P_1 passes across the flexural centre, we have $\tau = 0$. Therefore, we obtain from (4):

$$\oint \tau_s ds = -\frac{A\sigma}{1+\sigma} \iint y dx dy. \tag{6}$$

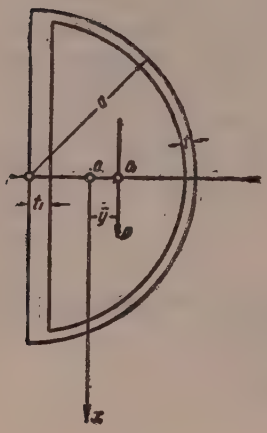

Fig. 1.

If the force P_2 passes across the centre of flexure, we have also:

$$\oint \tau_s ds = \frac{B\sigma}{1+\sigma} \iint x dx dy. \tag{7}$$

In order to calculate τ_s, it is necessary to use C. Weber's method for an unclosed section. For this purpose, let us cut our closed section, and let the whole value of the stress component in the direction of the tangent to the middle line at the place of the cut be T_0; then, at the distance s from it, according to C. Weber, we have:

$$T = T_0 - \int_0^s At\xi ds. \tag{8}$$

Here t is the variable thickness of the section, ξ is the distance of the points of the middle line from the axis Oy. Further we have:

$$T = t\tau_s, \quad T_0 = t_0\tau_s^0. \tag{9}$$

Taking this value of τ_s and substituting it in (6). we shall be able to calculate the unknown τ_s^0 from formula (6). Using formula (7), we have:

$$T = T_0' - \int_0^s Bt\eta ds, \tag{8'}$$

where η is the distance of the points of the middle line from the axis Ox. In order to calculate the coordinates of the centre of flexure $(\bar{x}, \bar{y})$, we have the formulae:

$$\left.\begin{aligned} P_1\bar{y} + M_1 &= 0, \\ P_2\bar{x} + M_2 &= 0. \end{aligned}\right\} \tag{10}$$

Here M_1 and M_2 are the moments of the forces T about the centre of gravity. It should be noted that the centre of gravity of the section does not generally coincide with the centre of gravity of the area limited by the middle line of the section, and therefore the right-hand sides of formulae (6) and (7) do not vanish, excepting in the case of the axes of symmetry. If we introudce the stress function according to the formulae:

$$\left.\begin{aligned} X_z &= \frac{\partial \varphi}{\partial y} - \frac{A}{2}[x^2 - f_1(y)], \\ Y_z &= -\frac{\partial \varphi}{\partial x} - \frac{B}{2}[y^2 - f_2(x)], \end{aligned}\right\} \qquad (11)$$

we obtain (2) for φ the following equation the twist τ being equal to 0)

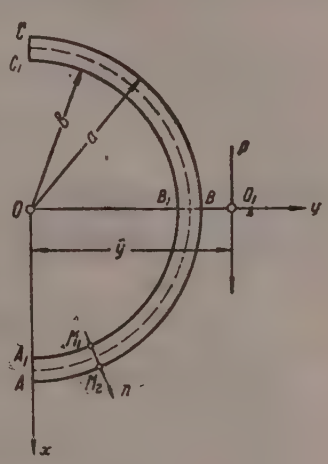

Fig. 2.

$$\frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2} = A\left[\frac{\sigma y}{1+\sigma} - \frac{1}{2} f_1'(y)\right] - B\left[\frac{\sigma x}{1+\sigma} - \frac{1}{2} f_2'(x)\right]. \qquad (11')$$

The following condition must be satisfied along the outer and inner boundaries of the section:

$$\frac{\partial \varphi}{\partial s} - \frac{A}{2}[x^2 - f_1(y)]\frac{\partial y}{\partial s} + \frac{B}{2}[y^2 - f_2(x)]\frac{\partial x}{\partial s} = 0. \qquad (11'')$$

In integrating it is possible to regard the arbitrary constant on one of the boundary contours (outer or inner) as equal to zero, but the arbitrary constant on the other boundary has the value φ_0, which is determined from the following condition:

$$\oint \frac{\partial \varphi}{\partial u} ds = \frac{A\sigma}{1+\sigma} \int\int y\,dx\,dy - \frac{B\sigma}{1+\sigma} \int\int x\,dx\,dy - \\ - \frac{1}{2} A \int\int f_1'(y)\,dx\,dy + \frac{1}{2} B \int\int f_2'(x)\,dx\,dy. \qquad (12)$$

From (3) and (11) we have:

$$\tau_s = -\frac{\partial \varphi}{\partial u} - \frac{A}{2}[x^2 - f_1(y)]\frac{\partial x}{\partial s} - \frac{B}{2}[y^2 - f_2(x)]\frac{\partial y}{\partial s}. \qquad (12')$$

Using (6) and (7) and the evident formula

$$\oint [Ax^2 dx + By^2 dy] = 0,$$

we have formula (12).

In formula (12) we take the contour integral round a closed middle line, and the double integral is taken over the whole area limited by the middle line.

For an approximate solution we apply the method explained in our article «On the Centre of Flexure of a Non-Closed Thin-Walled Section».

In the case of the Section shown in fig. 2 we obtain, according to this method:

$$\bar{y} = \frac{2at\phi}{(\pi t + 2t_1)(\pi t_1 + 2t)(3\pi t + 4t_1)}$$

$$\phi = t[16t_1 + 6\pi t - \pi^2 t_1] + \frac{\sigma}{1+\sigma}\pi t_1 (4t_1 - \pi t)$$

for $t = t_1$ we have

$$\bar{y} = 0{,}141\left(1 + 0{,}11\frac{\sigma}{1+\sigma}\right)a \qquad (13)$$

Applying (6) we obtain, counting of $\bar{y}_1$ from the centre of the circumference 0:

$$\bar{y}_1 = \frac{4(\pi+6)a}{(\pi+2)(3\pi+4)}\left[1 + \frac{\pi(4-\pi)\sigma}{2(\pi+2)(6+\pi)(1+\sigma)}\right] \qquad (14)$$

which coincides with (13) when the correct counting of c is made.

The given method is easy applied to the case compound contour. For this purpose it must be cut in to simple contours.

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PHYSICS

ON THE SEPARATION OF MAGNETIC VISCOSITY AND EDDY CURRENT LAG

By A. V. MITKEVIČ (MITKEVITCH)

(Communicated by V. Th. Mitkevitch, Member of the Academy, 28. VI. 1935)

As is known, the separation of magnetic viscosity and eddy current lag sometimes cannot be carried out because of the difficulties arising in calculating eddy current lag. In my opinion, in such cases, it is necessary to take advantage of the difference in the nature of the dependence of eddy current lag and magnetic viscosity on some special conditions (1). The present investigation was undertaken for the purpose of studying eddy current lag and magnetic viscosity in the case of $H=0$, after the breaking of the magnetizing current that excited some magnetic force H_m during five seconds. The reducing of magnetic force was carried out directly from H_m to $H=0$, as well as indirectly, with a five minute stop at certain magnetic force H'(1). As could have been expected, I have found that the time lag in magnetization due to eddy currents at $H=0$ depends, to a great extent, on the value of magnetic force H'. On the other hand, under the conditions of the present work, magnetic viscosity actually is not affected by the stop at magnetic force H'.

The sample investigated was one of the previously described iron rings (1) of shellac coated iron wire 0.1 mm in diameter, with coercive force $H_c=6$ oersteds. As can be shown by calculation, in this case eddy current lag becomes quite imperceptible after one thousandth part of a second from the instant of changing the magnetic force. Search coil and magnetizing coil were wound on this iron ring. The automatic gradual reduction of the magnetizing current to zero was carried out in all cases identically, during 0.5 second, by means of a pendelum, and ended in breaking the circuit of the magnetizing coil (1).

An additional coil of 2000 turns, wound on the investigated ring, was short-circuited to obtain the conditions equivalent to eddy currents. This short-circuited coil was made of insulated copper wire 0.8 mm in diameter. Hence, the conditions for the investigation of eddy current lag were equivalent, to a certain extent, to those in the solid iron specimens. In this case,

search coil was automatically connected to the galvanometer (fluxmeter type) after an interval of time of the order of one thousandth part of a second from the instant of breaking the circuit of magnetizing coil.

The following table presents in the fourth column the deflections of the galvanometer obtained during the influence of equivalent eddy currents in the cases of magnetic force changing directly from H_m to $H=0$, as well as with a stop at some magnetic force H'. In the third column of the table are given the changes of magnetic induction obtained by changing magnetic force from H_m to $H=0$ and from a certain value of H' to $H=0$. As could be expected, the deflections of the galvanometer caused by the equivalent eddy currents (fourth column) are in proportion to the corresponding previous changes of magnetic induction (third column).

Oersteds		Gausses			
H_m	H'	Changes of magnetic induction	Results of equivalent eddy current lag obtained with short-circuited additional coil	Manifestations of magnetic viscosity with superposed eddy currents arising in investigated iron wires	Manifestations of magnetic viscosity
10	—	2150	178	4.25	1.12
10	5	1430	111	3.73	1.12
10	2	740	59	3.60	1.12
10	1	370	29	3.50	1.12
10	0.5	170	14	3.34	1.11

In the fifth and in the last columns of the table are given the deflections of the galvanometer obtained with the broken circuit of the above mentioned additional coil of 2000 turns. In the fifth column are given the data obtained when the search coil was automatically connected to the galvanometer after the interval of time of the order of one thousandth part of a second from the instant of breaking the circuit of the magnetizing coil. These experimental data are due to magnetic viscosity with superposed eddy currents arising in the investigated iron wire. The last column gives the experimental results obtained in case of connecting the search coil to the galvanometer after ten seconds from the instant of breaking the circuit of the magnetizing coil and with the circuit of additional coil broken. In this case, the observed magnetic lag may be considered as due to magnetic viscosity only.

It may be noted that fivefold increase of the resistance of the circuit of magnetizing coil did not in any way affect the experimental data that are due to magnetic viscosity only and are given in the last column of the table, but slightly decreased the data given in the fourth column that are due to the equivalent eddy currents, without affecting the nature of the depen-

dence of these results on the value of H'. On the other hand, this increase of resistance of the circuit of magnetizing coil changed the dependence of the data given in the fifth column on magnetic force H'. Owing to the above mentioned resistance being increased fivefold, these results become actually independent of the value of H', as in this case magnetizing current attained a value practically equal to zero in much less time than in the case of smaller resistance. Of course, the manifestations of magnetic viscosity at $H=0$ depend, to a certain extent, on the pause at magnetic force H'(1), but this dependence becomes imperceptilbe when magnetic force H_m approaches saturation and the value of H' is large enough.

Conclusion

From this investigation it is clear that when $H=0$ the results of eddy current lag are in proportion to the previous changes of magnetic induction. On the other hand, the manifestations of magnetic viscosity at $H=0$ do not depend actually on the previous changes of magnetic induction, if the value of H_m and H' are large enough. Thus, it is seen, that when investigating magnetic viscosity at $H=0$, the superposed eddy current lag can be detected thanks to the specific influence of the previous changes of magnetic induction, i. e. the influence of the value of H' on the deflections of the galvanometer, this influence arising in the case of superposed eddy current lag.

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CHEMISTRY

ON THE ALKALOIDS OF THE LEAVES OF JABORANDI. VII

THE SPLITTING UP OF THE UNSTABLE ETHYL-PARACONIC ACID (RACEM-PILOPIC ACID) INTO OPTICAL ANTIPODES

BY N. A. PREOBRAŽENSKIJ and V. A. PREOBRAŽENSKIJ

(Communicated by A. E. Favorskij, Member of the Academy, 11. V. 1935)

β-ethyl-paraconic acid exists, as regards its structure, in two racemic and four optically active forms. One of the racemates, the so-called racem-isopilopic acid, is a stable form, the same as its two component antipodes. The other racemate, the so-called racem-pilopic acid, is unstable. α-pilopic acid, the product of a careful oxidation of pilocarpine, is an unstable substance easily converted into α-isopilopic acid. All the six β-ethyl-paraconic (pilopic) acids have been prepared by us synthetically, but the splitting up of the unstable racem-pilopic acid into its antipodes has not yet been published. This process presented certain difficulties in view of the low stability of both pilopic acid itself and its salts with alkoloids. So, for instance, the strychnine salt does not crystallize from aqueous solutions, while in alcohol solutions it decomposes with an evolution of strychnine. When different treatments were applied strychnine salts still remained a syrop.

The morphine salt is also obtained from water in the form of a syrop, but after drying it with alcohol and ether *in vacuo* and placing it, dissolved in absolute alcohol, in an ice-chamber, a crystalline precipitate is obtained with a melting point of 190°. The crystallization did not show any noticeable difference of fractions.

The cinchonine salt crystallizes from water and forms thick shining prisms with a melting point of 168—178°. But after oft repeated recrystallizations the decomposed salt produced an acid whose melting point was but slightly higher than that of the racemate.

Good results were attained when using brucine salts.

0.5 g of unstable racemic acid, whose melting point was 90—91°, were dissolved at room temperature in 2.5 cm^3 of water, and 1.24 g of brucine added to the solution. On vigourous shaking, the brucine rapidly dissolves, the clear solution becomes turbid, and then fine needles of brucine salt precipitated. The reaction mixture was left to stand overnight in an ice-

chamber. The precipitate left after draining amounted to 0.82 g. It was then twice washed with icecold water, 0.6 cm³ being taken each time. The weight of the precipitate obtained was 0.78 g. It was dissolved in 17 cm³ of water at 30°, and the solution was concentrated *in vacuo* at that temperature up to 2.5 cm³, 0.67 g of salt precipitating. The salt was recrystallized five times in this way. After that it was recrystallized four times more from absolute alcohol. Melting point 97.5—90°, but about 101° a certain cloudiness is still noticeable. After prolonged standing in a vacuum exsiccator, the melting point became 101—109°. It seems that this salt is a comparatively stable hydrate. When recrystallizing the salt from small quantities of water with heating, the process has to be repeated ten times.

To isolate free acid, an aqueous (8.4 cm³ of H_2O) solution of 0.32 g of brucine salt was decomposed with a theoretical quantity (1/10 *n*) of caustic potash.

On cooling the solution and letting it stand, 0.24 g of brucine separated and was drained. The filtrate was acidulated with a calculated quantity (1/10 *n*) of hydrochloric acid and evaporated dry *in vacuo* at 25—30°.

After extracting with ether, the acid was recrystallized from water; on recrystallyzing from 0.8 g of water, 0.4 g of acid yielded 0.3 g of acid in the form of long glittering needles whose melting point was 119.5—120.5°. A sample of this acid mixed with the initial unstable racemate melted at 88—104°. A sample mixed with α-isopilopic (stable) acid had a melting point of 86.5—95.5°, while that mixed with *l*-isopilopic (stable) acid, 80—92°. The acid is readily soluble in hot benzene and separates from cold benzene in the form of a fluorescent precipitate which, when drained, resembles fibrous asbestos. From ether it precipitates in the form of crystals. On adding petroleum ether to the ether mother liquors, crystals in the form of sheaves of glittering snow-white needles are precipitated in 1—2 minutes, while when the solution is left to stand the acid crystallizes as prisms. On recrystallization from chloroform alone or with an admixture of petroleum ether (melting point 50—60°), it is obtained as long (up to 5 cm) glittering needles whose melting point is 120.3—121.9°.

3 000 mg of substance: 5 829 mg CO_2, 1 723 mg H_2O

$C_7H_{10}O_4$ (158.08):	Calculated	C 53.14	H 6.38
	Found	C 52.99	H 6.42

This acid was found to be dextro-rotatory; 0.3324 g of substance in 9.734 g of water in a 2 decimetre tube at 27° gave $\alpha_D = +3.53$, whence $[\alpha]_D^{27} = +53.10$.

The acid was reconverted into brucine salt, then recrystallized three times from absolute alcohol and four times from water. The salt was decomposed after the manner indicated above, and the acid obtained after recrystallization from chloroform (1.8 g of acid+30 g of chloroform yielded

1.6 g) had a melting point of 120.8—121.8°. Rotation of the acid obtained: in 24.318 g of water in a 2 decimetre tube at 18.5°, 0.831 g of substance gave $[\alpha]_D = +3.495$; whence $[\alpha]_D^{18.5} = +52.57°$. Boiling the solution for 68 minutes hardly affected the rotation:

$$[\alpha]_D = +3.35, \text{ whence } [\alpha]_D^{21} = +50.39.$$

An attempt was also made to check up on the purity of the acid by means of the cinchonine salt.

1.2473 g of α-pilopic acid of m. p. 120—121.2° were dissolved in 18 cm³ of water and 2.3221 g of cinchonine added. The undissolved crystals were filtered off. After prolonged standing in the cold, crystals precipitated from the filtrate. Their melting point was 145—164°. The filtrate was evaporated and, as it could not be crystallized from ethyl alcohol alone, a mixture of alcohol and acetone had to be used (acetone cannot be used alone in view of the decomposition of the neutral salt into an acid one and cinchonine). The recrystallized salt (0.83 g, melting point 186.6—187.6°) was dissolved in water (23 cm³) and decomposed (18.06 cm³) with 1/10 *n* caustic soda and acidulated (15.25 cm³) with 1/10 *n* hydrochloric acid. The acid obtained (0.25 g, instead of 0.29 g) after extraction with ether was crystallized from benzene. It should be noted that the acid precipitate which separated during the crystallization from benzene fluoresces in passing light with a beautiful bluish tint, and in incident light with dirty yellow. Melting point of the acid is 121.2—122.2°. Rotation determined: 0.1662 g of substance in 4.840 g of water in a 1 decimetre tube gave $[\alpha]_D = +1.815$. Hence $[\alpha]_D^{18} = +54.60°$.

After distilling the water from the syrop containing the brucine salt the laevo-rotatory antipode, the residual salt of α-acid was eliminated by draining the precipitate which had separated in the cold. The syrop was evaporated *in vacuo*, and after a small sample dissolved in absolute alcohol, diluted with ether, and left to stand had crystallized, the whole syrop solidified into a compact crystalline mass, which was purified by repeated crystallizations from acetone.

The procedure of isolating the pure acid is the same as that for α-acid. It is crystallized from ether, chloroform, water, and benzene (also with fluorescence). Its melting point is 120—121.8°. It was found to be a laevo-rotatory acid; 0.3324 g of substance in 10 cm³ of water in a 2 decimetre tube gave $[\alpha]_D = -3.59$, whence $[\alpha]_D^{18.5} = -54.00°$.

2 866 mg of substance: 5 550 mg CO_2; 1 612 mg H_2O

$C_7H_{10}O_4$ (158.08): Calculated	C 53.14	H 6.38
Found	C 52.82	H 6.29

This work was started in 1929 under the guidance of A. E. Tschitschibabin, member of the Academy.

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GEOCHEMISTRY

THE GEOCHEMICAL CHARACTERISTICS OF PROTOCRISTALLIZATION

By A. E. FERSMAN, Member of the Academy

On the basis of our new concepts of energy, we shall subject to geochemical analysis various groups of mineral formations, beginning with those we call ultra-basic, or basic, rocks and class among the products of the earliest stages of protocrystallization. These are rocks of the type of dunites, peridotites, pyroxenites, anorthosites, partly gabbroid and noritic basalts with their effusive or vein facies, with a high melting point (crystallisation begins at 1600—1500°C). In the process of cooling they undergo partial liquation, the splitting-off of sulphide components, the separation of pneumatolites (mainly titano-phosphatic ones), while the residual magmas are preserved and acquire, owing to a higher content of volatiles and, more especially, of water vapour, some of the properties of pegmatites. In the process of crystallization we may distinguish several distinct phases (stages) according to my classification worked out on pegmatites. The order of crystallization is fairly definite and follows on the whole the rule of Rosenbusch and the Bowen series, with the exception of the final, more acid types, where a transition becomes noticeable to mesocrystallization somewhat agpaitic in character. In the list given below, the minerals contained in the rocks themselves and the segregations associated therewith are given in the order of time of their main crystallization. This admittedly involves a certain amount of schematization of a highly complex process, a sequence table of which may be of a statistical nature, and lays no claim to perfect accuracy in any given case, since the effect of the law of masses, temperature, pressure, catalysers, viscosity, etc. complicates the spatial and chronological relations.

As may be seen from the table *(v. p. 217)*, valence and hardness decrease with progressing crystallization. Of special interest is the gradual increase of $w = 1$ (univalent ions).

Synoptical Table of Chemical Elements of Protocrystallization (the even ones are printed in boldface):

Leading elements: **Mg, Si, Ti, Fe, Ni, Cr.**
Principal elements: **C, O,** Na, Al, P, **S,** Cl, **Ca,** V, Mn and 6 metals of the platinum group.
Secondary elements: (H), Sc, Co, Cu, **Zn, Ge,** As, **Pb,** Sb, Hg, Tl.
Accessory elements (drawn in from adjacent fields): K, **Sr, Zr,** Nb, Ag, Ta, **W,** Re, Au, **Sn.**

These elements form a well-defined field outlined on the appended Mendeléeff table. For comparison it may be stated that the field of siderophile

The principal minerals of protocristallization

Phases		Minerals	w, w*	Hardness according to Moos	Remarks
		Magmatic Stage			
ABC phases	1	Diamond	4	10	
	2	Metals Fe-Ni	3,2(?)	—	
	3	(Chloropatite)	1,2,5	(5)	Mainly in pneumatolites
	4	Corundum	3,(2)	9	
	5	Ilmenite	2,4	5—6	Oftener with titanomagnetite 16
	6	Spinel, noble	2,3	8	
	7	Chromite	2,3	7.5	Descends down to 15
	8	Magnetite	2,3	6.5—6	Cf. titanomagnetite 16; usually lower
	9	Graphite	4	1.5	
	10	Platinum alloys	4,3,3	4.5—4	Descends down to 14. Pt, Os, Ru, Rh, Pd, Fe
	11	Osmic iridium	4,4,3	7—6	
	12	Olivine	2,2,4	7—6.5	Magnesium varieties earlier, fayalite later
	13	Garnet (pyrope)	2,3,4	7—6	Magnesium varieties earlier, manganese after 18
	14	Enstatite (bronzite)	2,4	6—5.5	
	15	Hypersthene (diallage)	2,4	6—5.5	
	16	Titanomagnetite	2,3,4	6—5.5	In residual melts between 13 and 21
	17	Diopside	2,2,4	6—5	
	18	Hornblende (actinolite)	2,2,4	6.5	
	19	Biotite	1,3,4	3—2.5	First appearance of univalent cation
	20	Plagioclases	1,2,3,4	6.5—6	Calcium varieties earlier (about 13), sodium varieties later, up to 22
	21	Sulphides of Fe, Ni, Co, Cu	2,2,2,1	5—4	Chalcopyrite last
	22	Compounds of Pt with S, As, and Sb	4,3,2,3,5	7—5	
D—H phases	23	Scapolite	1,2,3,4	6—5	Appearance of volatile components
	24	Chromium garnet	3,2,3,4	6.5	
	25	Chromium vesuvianite	3,2,3,4	6.5	
	26	Serpentine	1,2,4	4—3	
	27	Chlorites	1,2,3,4	3—2	First foliated lattices
	28	Chromium chlorites	1,2,3,3,4	3—2	» » »
	29	Nickel chlorites	1,2,2,3,4	3—2	» » »
	30	Asbestos chrysot.	1,2,4	4—3	
	31	Brucite	1,2,1	2—5	Foliated lattice
	32	Talcum	1,2,4	1	» »
	33	Magnesite	2,2	4.4—3.5	
	34	Hydrocarbonates of Mg, Ca, Fe, Mn	2,2,1	3.5—3	Combining with crystallization water
I—L phases	35	Magnesium and Nickel silicates with H_2O	1,2,2,4	3—2	
	36	Hisingerite	1,2,3,4	3	
	37	Volkonskoite	1,2,3,4	1.5	
	38	Notronite	1,3,4	3.5—2.5	

* This column shows the valence of the principal elements of the compounds.

meteorites lies to the right of our zone, the field of granitic pegmatites, to the left (boundary marked by dotted line).

The characteristic features of these elements may be summarized as follows. Elements with even atomic numbers, even atomic weights, and even dominants, predominate. Very characteristic is the predominance of such elements as are multiples of 4 (i. e. those formed of heliogroups).

Even and high valencies (up to 4) predominate, the valency curve displaying a sharp maximum at 4 and 2; both very low and very high valencies are unknown. There is a marked predominance of the lowest ion radii of a given valency. The highest combining ratios (Lindemann's functions) predominate in nearly every case; this value, being an index of thermal stability, is very characteristic. Both the ion potential and the potential of ionization (according to the first electron) are generally rather high. The abundance of non-symmetrical ions with incomplete internal orbits leads to the predominance of coloured ions and of the resulting combinations, as well as to acute manifestations of paramagnetism.

Lastly, and this is more characteristic than anything else,—the energy values, i. e. Ek and VEk, are very high, and, with the exception of Li, Be, and F, the elements of protocrystallization show exactly the same maxima of energy coefficients as the corresponding groups of the Mendeléeff table.

As regards the atomic volume curve, the elements of protocrystallization occupy the lowest places, partly overlapping the siderophiles and the adjacent portions of the chalcophiles, and more particularly the lithophiles lying on the descending curves.

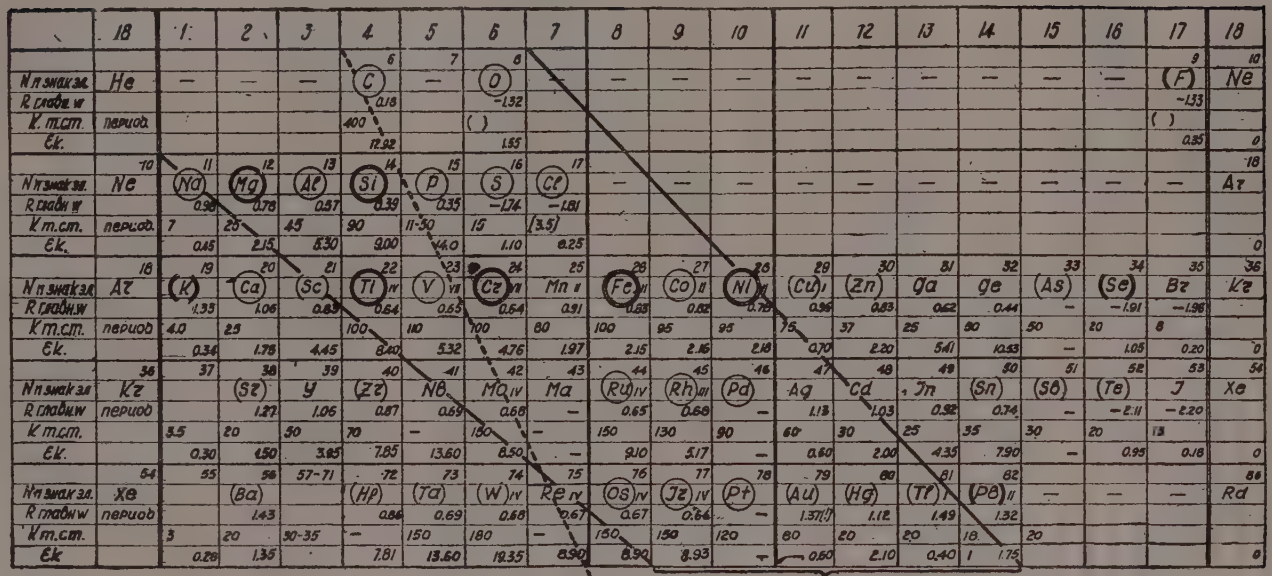
As regards crystallography and crystallochemistry, the compounds exhibit a striking predominance of even symmetry (more especially of the cubic and square systems), with even and mean values of coordination numbers (6,8).

The following conclusion suggests itself.

All the main indices, namely the evenness of the atomic numbers and the magnitudes of the atomic numbers, corresponding to the maximum values of packing energy according to Aston (i. e. the stability of the nuclei), the high (up to 4) and even valencies, the shortest ion radii, the low and even coordination numbers, the enhanced even symmetry of crystalline structures, the highest coefficients of thermal stability (Lindemann) and the lowest atomic volumes, ion potentials and ionization potentials, and, lastly, the highest values of ionic energy (Ek and VEk), of lattice energy (U), all this definitely and unmistakably points to the fact that protocrystallization (i. e. basic and ultra-basic magmas) comprises atoms endowed with the highest stability of the nucleus, with the greatest mechanical, thermal, and electrostatic strength of the electronic shells and stability of the lattices, combined with a minimum of stored-up free energy.

This quite remarkable situation is not only characteristic of protoformations as a whole, but arises mainly in the early stages of crystallization, while it is less pronounced in the final ones; applied to a particular case, it may be taken to illustrate the general law of crystallization of silicate melts, whose final stages are granitic pegmatites and aqueous solutions, and where we have another extreme point, that of the accumulation of the most mobile, migratory, the least stable, and the least resistant atoms and lattices.

Table of Geochemical Features of Protocrystallization.



N и знак. эл. = *N* and sign of elements. *R* главн. *w* = Radius of main *w*. К. т. ст. - Coefficient of thermal stability. Период = Period. Правая граница тегокристал. — Поле протокристализ. = Right hand boundary of tegocrystal. — Field of protocrystallization. Ring, single of double, denotes special role of element in the processes of protocrystallisation). The radii are given in Ångströms, the *EK*'s in conventional units × 256. 1 per mole; coefficient of thermal stability according to Lindemann (= *b*).

It is easy to see that this conclusion is of the highest theoretical importance. Not only does it give the atomic characterization of the crystallizing process of basic magmas, not only does it explain the progress of the process, but it also suggests the laws of differentiation and of the spatial and chronological distribution of chemical elements.

These investigations mainly show that protocrystallisation corresponds to a certain maximum energy lose and characterizes a definite geosphere of the earth endowed with a minimum stored-up energy of its compounds, contrary to the higher zones of the earth (granite massifs, sedimentary rocks, hydrosphere, and atmosphere).

The above features of protocrystallizations account for some peculiarities of their practical use. It is therefore natural that they should include the following groups of minerals, viz.:

1) stable building materials containing Mg, Ca, Si, Fe;

2) stable metal roofings Fe, Ni, Cr, and also the metals Pt, Pd, Rh, Ru;

3) chemically and thermally stable insoluble substances: (Zr, Nb, Ta), the metal Pt, and the Ni, Co and Cr groups;

4) fire-proof materials: corundum, periclase, chromite, talcum, magnesite;

5) precious (hard) and technical stones: diamond, spinel, corundum, chrysolite, pyrope, and others.

The laws outlined above suggest a number of problems of great importance in geochemistry and more especially in petrochemistry; both the phenomena and the processes are, however, too complex in themselves to anticipate a full agreament of data and the absence of occasional exceptions. The scheme outlined above cannot be expected to cover all the minerals and elements without exception, but a set of conditions may be suggested to account for these exceptions (especially in connection with the formation of complex ions of Fe^{+3}, Ti^{+3}, and others. At any rate, the general geochemical nature of the phenomena of protocrystallization is very well defined and becomes still more pronounced if they are compared with other geochemical complexes, a subject that will be treated in subsquent papers.

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GEOCHEMISTRY

SULPHUR BACTERIA IN THE «PINK» WATERS OF THE SURUKHANI OIL FIELDS AND THEIR SIGNIFICANCE IN THE GEOCHEMISTRY OF WATER

BY V. T. MALYŠEK and A. A. MALIANC

(Communicated by (V.I.Vernadskij, Member of the Academy, 21. IV. 1935)

One of the characteristic traits of the geochemical history of sulphur is the enormous role bacteria play in the chemistry of vital processes.

«It may be considered as established that sulphurous compounds are formed above the oxygen surface only under special conditions, mainly in the course of biochemical processes of the earth's crust when the energy due to the change of organic substance is set free (1)». The biochemical processes determining the sulphur cycle are based upon reducing reactions (2) which lead to the formation of hydrogen sulphide, the chief reducing agents being the anaerobic bacteria which decompose the sulphates, namely, *Microspira desulphuricans* and *Microspira aestuarii* discovered by Beigerinck and van Delden.

Simultaneously with the evolution of hydrogen sulphide, there occur oxidizing processes, which are considerably accelerated by the activity of the so-called sulphur bacteria, thoroughly studied by Vinogradskij. Sulphur bacteria may be divided into two large groups,—the colourless ones and the purple coloured. These last, under conditions favourable for the oxidation of hydrogen sulphide, are comparatively wide-spread and colour aqueous solutions red. Purple bacteria have been discovered in almost all seas and in many lakes (4). The colourless sulphur bacteria are likewise widely distributed. The investigations of B. L. Isačenko (3) have helped to explain the cause of the pink colour of the waters of lake Mogilnoye on the Kildin island, on the boundary of the evolution of hydrogen sulphide, at a depth of 13 m, and to understand the nature of bacterial processes. The activities of microorganisms were usually considered to be limited to the biosphere and adjacent regions. But «the discovery by E. Bastin and N. Ušinskij (5) of live bacteria in the oil bearing waters at a depth of over one kilo-

metre, both in North America and in the Apsheron peninsula, have shown that the boundary of the biosphere should be extended down much deeper than the oxygen surface. Anaerobic life, which may be much more developed in deep bed waters than we imagine at present, should be taken into consideration (6)».

The presence of an abundant microflora in the sedimentary rocks of oil fields, in the waters, and in the oil itself (7), indicates that the activity of anaerobic bacteria does not cease with the burial of organic matter, which points to the biochemical nature of oil formation (8). The presence of sulphur bacteria has been accurately established and the fall of ion concentration of SO''_4 has been determined in the rocks (9) and waters in the vicinity of oil, which is due to the transition of SO''_4 into less oxidized anions: $\rightarrow SO''_3 \rightarrow S_2O''_3 \rightarrow S''$. The last investigations of the Microbiological Laboratory of the Geochemical Department of the Azerbaijan Oil Research Institute have established, by means of a microbiological examination of 25 samples of oil-bearing waters of the Surakhani oil fields, the presence of purple bacteria and of the thio-acid group. The waters from the «NKP I» bed, wherefrom a number of wells produce pink water together with the oil, were investigated. The depth of the wells ranges from 1363 to 1705 m. All the wells exploited were flowing well at the beginning with a flush production of from 1000 to 400 tons daily with no noticeable admixture of water. After several months exploitation, the oil production of the flowing wells decreased, and there appeared a small admixture of water of a definitely pink colour. Observations of over 18 months have shown that the appearance of pink waters is to be observed in all the wells of the eastern flank of the Surakhani fold and that the boundary of the disappearance of coloured waters in the western part lies along the axial line of the fold. The colour is much deeper in those wells which produce oil with only an insignificant admixture of water. An increase in the percentage of water (up to 50 per cent) led to the disappearance of colour. All the samples of water under the microscope (water smears) were remarkable for the great quantity of bacteria, the microflora consisting of rods of different shapes and of spirae. Small bodies externally resembling chromation cells occurred in the pink waters. To obtain cultures of purple bacteria, cylinders 50—60 cm high were inoculated with samples of pink waters. Some soil consisting of clay mixed with chalk with the addition of $CaSO_4$ and $MgSO_4$ was put in the cylinders and wetted with van Delden's medium. Growth of purple bacteria was obtained in samples of the water from well No 75546 (depth 1389 m) taken March 28, 1934, well No 76639 (depth 1363 m) taken May 14, 1934, and also in samples of pink waters taken for comparison from a small lake lying within the precincts of the oil-fields.

It is characteristic that in all lake water cultures there was always to be observed a growth of algae parallel with that of the purple bacteria, while in cultures of pink waters from the wells algae were absent.

The chromation cells from the cylinder with the lake water culture were much larger under the microscope than the purple bacteria from the cylinders with oil water cultures.

The inoculation of tubes containing Bawendamm's solid medium with the pink films gave positive results. Immediately on the arrival of the samples in the laboratory, examinations were made for the presence of other bacteria groups besides the purple bacteria. In all samples *Microspira desulfuricans*, the microbe that reduces sulphates, was found. The process of denitrification was also observed to occur in all the samples. Inoculations of Nathanson's medium gave an excellent growth of thio-acid bacteria, the formation of sulphates being observed. The discovery of purple and thio-acid bacteria at considerable depths (over 1300 m) in the bed waters of oil fields does not accord with the conditions necessary for the life processes of these microorganisms. Hydrogen sulphide and light are necessary for the growth of purple bacteria, while the thio-acid ones need oxygen also, both having the power of assimilating free carbon dioxide and of oxydizing sulphurous compounds to sulphates. Cases are known when purple bacteria were kept for 9 years in a sample of water from lake Mogilnoye in a dark cupboard and did not perish ([11]). But is the preservation of life processes of bacteria during geological periods possible? There are indications of the distribution of microflora downwards to great depths in a latent state ([12]), but under what conditions does it develop?

The presence of thio-acid bacteria is the most interesting fact. Their role in the biosphere has been sufficiently well studied. It is to be supposed that conditions favourable to them exist in the deep parts of sedimentary rocks. In this respect the gas-lift method of oil production used in some wells and supplying oxygen of the air may be of considerable importance. The presence of thio-acid bacteria is confirmed by chemical analyses of oil waters, the content of sulphates in the waters being increased where these bacteria are present. So the content of SO''_4 in oil waters ranges from traces to 5.10^{-3} per cent, while at «NKP I» it attains $35 \cdot 10^{-3}$ per cent. The same is observed for the underlaying horizon «NKP II» of the Surakhani region, where there occur waters of a yellowish-green colour and with a sulphate content higher than usual. The oil microflora of these last has not yet been studied, but, apparently, the presence of thio-acid bacteria will be confirmed here also.

This points to the possibility of a process of oxidation in the direction of $S'' \rightarrow S_2O_3'' \rightarrow SO_3'' \rightarrow SO_4''$, i. e. a process opposite to the one of sulphate reduction, the latter nevertheless remaining dominant, as is confirmed by the widely known presence of hydrogen sulphide fermentation and the occurrence of hydrogen sulphide alkaline waters in the bottom layers of the upper and lower horizons of the «productive» beds of the Apsheron peninsula. The question of the effect of these processes on the sulphur content of the oils themselves and of the various bitumens is also interesting.

The insignificant sulphur content of the Baku oils is possibly due to the oxidizing processes coused by the sulphur bacteria.

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BIOCHEMISTRY

VARIATIONS IN KEEPING QUALITIES OF DIFFERENT VARIETIES OF VEGETABLES AND THE REASONS THEREFORE

By B. A. RUBIN and V. E. TRUPP

(*Communicated by A. A. Richter, Member of the Academy, 5. VI. 1935*)

The material here set forth is part of the results of a lengthy investigation of the problem of varietal difference—an investigation that has already been carried on during the course of three years in the Biochemical Laboratory of the Institute of Vegetable Crops. We have tried to connect varietal difference according to one or another feature with inner biochemical varietal characters; in this work a comparison is being carried on throughout the whole life cycle of the plant. The present article is devoted to the keeping qualities of vegetables as a varietal character.

A different stability of different varieties has been noticed by literally all investigators working in this field. Without citing here the titles of a great number of works or naming their authors, we will point only to the fact that in hardly any of these articles has any attempt been made to explain the differences observed or to establish their causes.

A number of works have been published during the last few years in which the authors attempt to relate high keeping qualities to content of dry substances [Cerevitinov (1), Jakuˆkin(2)], organic acids and nitrogen [the works of Archbold (3) and of Haynes (4) and others, on apples] with value of pH and activity of hydrolytic ferments [Rubin—sugar beets (5)] and so forth. Suchorukov (6), on the basis of the works of Lepeshkin (7), connects varietal differences in keeping qualities of carrots with so-called bio-catalytic strength of the juice (negative correlation).

In a number of studies, Richter and Suchorukov (9) found that the immunity of different varieties of sunflowers to Orobanche Cumana is connected negatively with the activity of peroxidase, by which, it would seem, the earlier deductions of Comes are confirmed. Quite recently there have been made a number of investigations of the oxidation-reduction potential of the vegetable cell and its connection with biochemical features. In particular, a relation has been established for potatoes between the magnitude of the potential and the so-called mosaic diseases (10, 11).

In the investigations undertaken by us, the purpose was to connect varrietal keeping qualities with the general dynamics of substances when kept in storehouses.

The work was carried on with onions and cabbages, two varieties for each culture: onion «Spanish»—annual variety, poor keeping qualities; onion «Msterski»—biennial, good keeping qualities; Cabbage «Amager»—a variety with a very long period of vegetation (180 days), keeps excellently for a period of 5 to 6 month; cabbage «Number One»—a quick-maturing variety (vegatation period 80 to 90 days), very poor keeping qualities.

The vegetables were kept in a special storehouse out of which the samples placed there for experiment were taken every 40 to 45 days.

The method of determination described in the article by Pubin and Trupp «Biochemical Processes in the Conservation of Vegetables» [13] was used. In Table 1 are shown the data on the change of composition of onions which had been kept for 140 days (only the initial and final figures are given).

Table 1

Dynamics of the Composition of Onions during Keeping
(In Percentage of the Raw Test-Portion)

	«Spanish»		«Msterski»	
	At beginning of storage period	At end of storage period	At beginning of storage period	At end of storage period
Loss in weight	—	20.5	—	21.1
Dry substance	10.18	6.92	15.01	9.81
Monosaccharides	2.88	3.23	1.80	2.99
Saccharose	3.76	0.97	8.47	3.01
Total of dissoluble sugars	6.64	4.20	10.27	6.00
Cellulose	0.59	0.74	0.59	0.67
Total nitrogen	0.21	0.18	0.26	0.22
Protein nitrogen	0.10	0.06	0.13	0.11
Catalase	13.4	6.5	15.9	9.2
Saccharase	4.9	42.8	3.5	47.3

It can be seen from this table that the «Msterski» onion—one of the well keeping varieties—shows the highest losses of sugar. Along with the general amount of loss, extremely characteristic for these varieties, is the qualititative composition of the carbohydrate complex, the relation between certain forms of sugars.

Thus, for example, the relation of saccharose to monosaccharides changed during the time of conservation in the following manner (in percentages).

Table 2

	«Spanish»	«Msterski»
Nov. 23	138	490
Jan 17	70	230
March 6	81	144
April 13	32	106

While, in automn, the quantity of saccharose in the Spanish onion exceeds the quantity of monosaccharides by some 40 per cent, in the Msterski onion the saccharose is five times greater then the monosaccharides.

During the period of keeping, this quantity fell a great deal in the case of both onions; however, in the Msterski onion, it was, at the end of the period, approximately as high as in the Spanish onion at the beginning.

With respect to the data on ferments, one cannot but be struck by the exceptional growth in activity of saccharase in both varieties of onion. Doubtless one of the reasons for this growth is the increase in acidity of the juice, with which, in its turn, the suppression of the activity of catalase is also probably connected.

Great interest attaches to the decreased content of protein nitrogen that we established for the Spanish onion—about 40 per cent in comparison with the beginning stage—as contrasted with the perfect immutability of this factor in the Msterski onion. One of the important biochemical indices of poor keeping qualities in the Spanish onion is the great mobility of the protein complex, the intensive hydrolysis of proteins.

Analysis of cabbages was carried on for leaves and stalk separately. In Table 3 are shown the data for changes in content of the cabbage components during keeping (in this case, too, only the initial and final data are given).

Varietal differences which may be little noticeable when reviewing the general progress of the transformation of substances under keeping, stand forth with greater emphasis when the varieties are compared on the basis of the intensity with which these transformation take place. Varieties differ not only in the total amounts of loss of carbohydrates, but in all their dynamics.

Table 3

Dinamics of the Basic Substances in Cabbage when Kept for 140 Days
(In Percentages of the Dry Test-Portion)

	«Amager»				«Number One»			
	Leaves		Stalk		Leaves		Stalk	
	At beginning of storage period	At end of storage period	At beginning	At end	At beginning	At end	At beginning	At end
Dry Substance	7.68	5.46	9.68	8.97	6.59	6.33	10.28	10.74
Monosaccharides	3.95	2.18	2.13	1.09	3.43	3.26	2.82	2.10
Disaccharides	0.41	0.10	1.84	0.90	0.14	0.00	2.08	2.38
Polysaccharides	0.40	0.25	0.61	0.41	0.52	0.21	0.39	0.39
Cellulose	0.68	0.94	1.13	1.23	0.66	0.60	0.93	0.89
Total nitrogen	0.22	0.20	0.35	0.55	0.21	—	0.44	—
Protein nitrogen	0.11	0.08	0.18	0.21	0.11	—	0.21	—
Catalase *	15.1	18.8	14.8	22.0	14.7	20.7	14.1	22.3
Saccharase	5.9	4.4	3.5	3.6	5.1	5.7	4.5	9.2
Amylase	24.8	22.6	26.0	25.5	24.0	22.5	25.5	28.7
Cytase	6.3	5.2	3.8	3.0	5.7	4.9	5.0	6.5

From the table it is evident that the general amount of loss of sugar in the Amager variety is higher than in the Number One (47 per cent as against 15.5 per cent).

Here again is repeated the relation that we established for the onions; the variety of cabbage characterized by good keeping qualities, loses considerably more suger during the period of keeping than the variety that spoils quite quickly (Number One).

In correspondence with what we established for onions, in the Amager cabbage the ratio of disaccharides to monosaccharides is much greater than in the Number One.

Table 4

Ratio of Disaccharides to Monosaccharides in Cabbages

	Amager		Number One	
	Leaves	Stalk	Leaves	Stalk
Beginning of the storage period	1 : 10	1 : 1.2	1 : 25	1 : 1.3
End of the storage period	1 : 22	1 : 1.2	—	1 : 2.0

The most outstanding is the difference between varieties in the respect of the relation between the loss of sugar and fall in percentage of dry substances. From Table 3 it is evident that while the loss of dry substances in the Amager cabbage fully corresponds to that of sugars, there is a great discrepancy between these losses in the leaves of the Number One cabbage (the loss of dry substances constituted here only 40 per cent of that of sugar). An analogous relation exists for the stalks, too. This characteristic of the variety is doubtless of great significance.

The data for change of activity of ferments in the two varieties are shown in Table 5.

When we compared the activity of ferments in the two varieties of cabbage in autumn, we observed almost equal values for both. However, each has an entirely different dynamics of activity of ferments. In the Amager variety we observe quite a distinct expression of the tendency toward a decrease of activity of the hydrolytic ferments during the process of keeping, while in the Number One the activity of the latter is markedly heightened. Amongst varietal differences, too, we note that in the Amager the activity of saccharase

* Activity of ferments is expressed in cm^3 of $KMnO_4$ per 1 gram of raw test-portion.

Table 5

Change in Activity of Ferments in Cabbages
(In Percentage of the Initial Activity)

	Amager		Number One	
	Leaves	Stalk	Leaves	Stalk
Saccharasé	−25.0	− 7.1	+11.4	+608.0
Amylase	− 1.9	+ 7.8	− 6.2	+ 30.6
Cytase	−53.4	−25.3	−13.9	+ 34.5
Catalase	+24.3	+48.6	+40.4	+ 62.6

and cytase is higher in the leaves, while in Number One these ferments are more active in the stalk. In such a turbulent activation of hydrolytic ferments during the keeping of Number One we cannot but see one of the basic causes of its poor keeping qualities. This fact seems to us to be of especial importance in connection with the discrepancy discovered between the loss of sugar and that of dry substance. We are of the opinion that these facts are related to each other in the most intimate way, that in the case of cabbage Number One, we have an example of a rupture of the coordination between the hydrolytic and oxidational systems of the plant. Apparently here the anaerobic phase of respiration is carried on normally, while the final—aerobic one—for some reason or other is retarded. This results in an incomplete oxidation of the respiratory material and an accumulation in the cell of some intermediate products of respiration. These substances may exert a toxic action, which causes a weakening of the resistance of the cell or its death, after which the cell is preyed upon by microorganisms.

Thus one of the reasons for the low keeping qualities of the Number One cabbage is the rupture in the oxidation process. No doubt the magnitude of the ratio of saccharose to monosaccharides has a great significance in determining the keeping qualities of different varieties. This quantity is a reflection of a number of conditions in the cell and above all expresses the trend of the activity of saccharase. A low ratio evidences a weakly synthesizing action of the ferment, which cannot but find reflection in the keeping qualities. No less important is the fact that both in the onion and in the cabbage, we have a greater loss of sugar, a greater energy for expenditure of reserve substances in the varieties characterized by high keeping qualities. The biochemical nature of good keeping qualities lies, thus, neither in weakened metabolism nor in a lowered expenditure of plant substance. On the basis of the data obtained, we are inclined to think that it is precisely a high energy of expenditure of carbohydrates in the Amager variety that is one of the basic reasons for its high keeping qualities. Our next important problem is to ascertain the nature of the intermediate products of respiration that accumulate in the cells of Number One cabbage.

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BIOCHEMISTRY

ON THE CHARACTERISTICS OF THE AMYLASE OF CABBAGE

By B. A. RUBIN and V. E. TRUPP

(Communicated by A. A. Richter, Member of the Academy, 5. VI. 1935)

During a study of the fermentative system of some vegetables, our attention was drawn to the exceedingly sharply expessed activity of amylase in cabbage.

The following table may be cited as providing a comparison of the activity of this amylase with those of other vegetables:

Table 1

Name of the vegetable	Activity of the ferment in mg of maltose per gram of dry substance
Beet «Bordo Gribovskaya» (root)	30.0
Onion «Msterski» (bulb)	92.8
Carrot «Nantskaya» (root)	267.0
Cabbage «Amager» (head)	1 411.0

Cabbage leaves are almost 50 times richer in amylase than beets, 15 times richer than onions, and more than 5 times richer than carrots. Supposing a direct comparison of the activity of ferments possible, we must admit that in the cabbage, for example, amylase is more active than saccharase.

We may illustrate the above statements by the following data (experiment of 1933).

Table 2

Name of variety	Activity of the ferments in mg of sugar per gram of dry substance	
	Saccharase	Amylase
Amager	298	1316
Kashirka	257	1633
Number One	214	1052

Again, the high activity of amylase arouses especial interest for the reason that the starch content of this vegetable is quite inconsiderable and approaches zero in the matured plant.

In connection with this, the supposition appears quite probable that in the present case we have to do with a ferment that is not characterized by a strictly specific action.

It is also possible that in the so-called «amylase» there is a whole complex of ferments, in each of which a specific action is conserved in full degree.

The latter supposition is the more probable in that many investigators (Wijsman, Pringsheim, and others) are generally inclined to look upon amylase as a complex of two ferments—amylase and amylobiase, found in different proportions with respect to each other*.

Cabbage, together with amylase of high activity, posseses still another extraordinarily interesting characteristic, which we succeeded in revealing in our work on keeping qualities. Cabbage is almost the only vegetable in which, during the time of keeping, the cellulose content noticeably decreases.

It is interesting that in the different varieties of cabbage, the amounts of the decrease are different and there exists a definite connection between the decrease and the activity of the ferment.

Table 3

Name of variety	Decrease in cellulose content after keeping for 150 days (in percentage of the initial amount)	Activity of amylase in mg of maltose per gram of dry substance
Kashirka	30.3	1633
Amager	21.4	1353
Number One	6.7	1052

The perfect regularity of the increase of loss of cellulose in connection with an increase of activity of «amylase» compels us to suggest that in this case amylase is accompanied by a ferment that is capable of hydrolysing cellulose itself or some of the other carbohydrates forming the cell walls of cabbage (cytase or cellulase).

Here we may see an analogy with the fact of the joint action of cytase and amylase in the sprouting of seeds established by Brown and Morris (2), as likewise by Brown and Escomb (1). Brown, as is well known, looked upon the cytase of grain as an independently existing ferment (for example, the cytase acting in the sprouting of barley, whose role reduces to the hydrolysis of the cell walls). In opposition to Brown, Reinitzer (3) denied the existence in sprouting barley of a special enzyme dissolving the cell walls, and considered that the capability of effecting the latter action is typical of amylase itself. Without dwelling in more detail on this question, we remark merely that the fact of the simultaneous existence in sprouting grain of two elements, amylo- and cytolytic, has been now firmly established.

In experiments in the keeping of cabbage in the years 1933 and 1934, we studied the activity of amylase in parallel with that of cytase.

The method of determination was the following. A test-portion of cabbage weighing 20 grams was comminuted in a porcelain mortar and transferred with addition of water into flasks graduated to 200 cm³ (dilution 1:10). For two hours an extraction was carried on, with periodic shaking of the extract, after which the flasks were brought to the mark and out of them tests were taken in order to determine the activity of the ferments. Cytase: 20 cm³ of water and 10 cm³ of acetate buffer (pH = 5) were poured into two

* We do not here touch upon the question of the division of amylase into dextrinogenous and saccharogenous forms.

Ehrlenmeyer's flasks. In the control flask there was added 1 cm³ of 30 per cent KOH for the purpose of inactivating the ferment.

Then 20 cm³ of stirred ferment culture, 0.5 grams of comminuted starch-freed hemicellulose from cabbage, and 1 cm³ of toluene were added into both flasks.

The flasks were corked and placed in a thermostat (temperature 30°C) for 18 hours.

The ferment in the experimental flasks was inactivated by the addition of 1 cm³ of 30 per cent KOH.

The suspension was filtered; in the filtrate sugar was determined by Bertrand's method.

The difference between the experiment and the control for each gram of test-portion was taken as the activity of the ferment.

The data from one of our investigations of the «Amager» cabbage are here presented.

Table 4

Activity of Ferments in cm³ of 0.1*n* $KMnO_4$ for 1 Gram of Raw Test-Portion

Date	Leaves		Stalk	
	Amylase	Cytase	Amylase	Cytase
November 16, 1933	24.8	6.3	26.0	3.8
January 8, 1934	25.3	5.3	25.1	3.5
February 21, 1934	22.1	2.8	22.6	2.5
April 3, 1934	22.6	5.2	25.5	3.0
May 9, 1934	24.4	3.0	28.1	2.8

By this work it was possible to establish beyond any doubt the existence in cabbage of a ferment capable of hydrolysing hemicellulose (cellulose?) to the extent of reducing sugar. We see that the content of this ferment does not have a constant value, it varies considerably; however, this variation is typical not only of cytase, but of all other ferments studied by us, as is apparent in the case of amylase.

This ferment * is considerably behind amylase in activity, but is at the same time, quite near to that of saccharase.

Figures presented below are the mean derived from the data we obtained during the whole period of keeping.

Table 5

Name of variety	Activity of the ferment in cm³ of 0.1*n* $KMnO_4$ per gram of the raw test-portion		
	Saccharase	Cytase	Amylase
Amager	4.4	4.2	24.2
Number One	4.7	4.5	23.1

The activity of cytase in the leaves is different from that in the stalk as is seen from the following data:

* In the future we shall, for the sake of brevity, call this ferment cytase.

Table 6

Name of variety	Activity of cytase in cm^3 of 0.1n $KMnO_4$ per gram of raw test-portion	
	Leaves	Stalk
Amager	4.51	3.12
Number One	4.68	5.22

From the figures shown in this table it is apparent that different varieties of cabbage vary not only in the general content of cytase, but also in the distribution of the ferment within the plant.

While in Amager (late variety) the part richest in cytase is the leaves, in the early variety of Number One the higher content of cytase is in the stalk. The richness of the stalk of Number One in cytase is still more noticeable, if it be compared with the stalk of Amager, in which the cytase is almost twice less than in the former.

We consider this fact to be of extraordinary importance and interest, since we connect it with the ability of the stalk of Number One to «awaken» earlier, and with the general higher tonicity of this variety.

It ought to be especially noted that the cytase content is characteristic of the cabbage itself and is not at all the result of infection of the cabbage by microorganisms.

Thus, for example, in our experiments in keeping cabbage in sterile conditions, the activity of the cytase was, in this case, 4.1 (Amager variety). The same cabbage, when artificially infected with a culture of the fungus *Botrytis cinerea* gave a cytase activity of 6.0.

Of course, after infection with the fungus, an increased activity of the ferment, amounting to $1^1/_2$ times, was to be observed*. At the same time, the data obtained establish beyond any doubt the presence of the ferment immediately in the tissues of the higher plant, independently of the influence of microorganisms.

At the present time, we are carrying on a further study of the ferment by means of isolating it from the cabbage.

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* As a result of the addition of the ferment of the fungus to the ferment of the cabbage.

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ZOOLOGIE

ÜBER *DYSPONETUS PYGMAEUS* LEVINSEN UND *EUZONUS ARCTICUS* GRUBE

Von N. ANNENKOVA

(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d. 19. VI. 1935)

Unter dem Polychaetenmaterial der fernöstlichen Expedition des Zoologischen Instituts vom Sommer 1934, welches aus der Bucht Sjauchu im Nördlichen Japanischen Meer stammt, entdeckte ich bei der Bearbeitung desselben zwei sehr interessante Formen, nämlich den *Dysponetus pygmaeus* Levinsen und den *Euzonus arcticus* Grube.

Der *Dysponetus pygmaeus* war bisher nur als von der Küste von Südgrönland, von der atlantischen Küste Nordamerikas (Eastport, Maine) und von der Hope-Insel am Südende Spitzbergens stammend bekannt. Unser Fund bedeutet also eine wesentliche Erweiterung des Verbreitungsareals dieser Art.

Genaue Angaben über das Vorkommen von *Euzonus arcticus* fehlen in der Literatur und Grube, der diese Art beschrieben hat (6), gibt nur die nördlichen Meere als Fundort an. Augener schreibt (3), dass diese Exemplare im russischen Eismeer erbeutet worden sind, während Okuda (11) aus mir unbekannten Gründen annimmt, dass sie aus dem Weissen Meer stammen. Spätere Angaben, die das Vorkommen dieser Art in arktischen Meeren bestätigten, liegen nicht vor. Dieser Umstand ist recht merkwürdig, da seit der Zeit der Entdeckung und Beschreibung dieser Art (1866) verschiedene russische Expeditionen ausgedehnte und planmässige Forschungsarbeiten an der Murmanküste, im Barentz-Meer, Weissen Meer und anderen russischen Meeren des Nordens ausgeführt haben: fast sämtliches von diesen Expeditionen erbeutete Material ist schon bearbeitet, wobei aber Vorkommen von *Euzonus arcticus* nicht festgestellt wurde. Es ist natürlich möglich, dass er in diesen Meeren noch nachgewiesen werden wird, wie das mit der *Manayunkia arctica* Zenkevich der Fall war, andererseits ist aber auch möglich, dass die Fundortangabe bei dem Material, welches Grube vorlag, nicht richtig war und dass es sich also überhaupt nicht um eine arktische Art handelt.

Dysponetus pygmaeus Levinsen (1897)

Dysponetus pygmaeus Levinsen 1833 (10); *Taphus hebes* Webster et Benedict 1885 (12); *Dysponetus pygmaeus* Augener 1914, 1928 (1,2); Fauvel 1914 (5)

Von der fernöstlichen Expedition des Zoologischen Instituts sind im Sommer 1934 etwa 25 Exemplare sehr kleiner *Chrysopetalidae* erbeutet worden, die ich als *Dysponetus pygmaeus* bestimmte. Levinsen (1897) gibt eine ausführliche Beschreibung dieser Art und recht gute Abbildungen, die einen genauen Vergleich unserer Exemplare mit der grönländischen Form ermöglichen. Ich konnte nicht den geringsten Unterschied zwischen diesen beiden Formen bemerken. Die Beschreibung unserer Exemplare folgt.

Körper länglichoval, aus 14—15 Borstensegmenten bestehend, farblos und halbdurchsichtig. Dorsale Borsten etwas auf die Dorsalseite gebogen, diese jedoch nicht deckend, wie das bei anderen Vertretern der Familie *Chrysopetalidae* der Fall ist. Korperlänge 2—3 mm. Kopfteil von halbrunder Form, aus dem Kopflappen und dem mit ihm vollständig verschmolzenen Buccalsegment bestehend. Kopflappen ist mit auf die Ventralseite verschobenen dicken, kurzen zylindrischen Palpen und drei kleinen Antennen von ovaler Form versehen. Die paarigen Antennen sind am Vorderrand des Kopflappens befestigt, die unpaarige ist etwas auf die Dorsalseite verschoben. Augenflecke fehlend; ich konnte solche sogar an lebenden Exemplaren nicht wahrnehmen. Buccalsegment ohne Borsten, nur mit einem Paar Tentakelcirren, das Form und Grösse von Antennen hat. Ausserdem befinden sich auf der Ventralseite am unteren Rand der Mundöffnung noch zwei kurze konische Papillen «processus palpiformes» (Levinsen, p. 11).

Aus vorstehender Beschreibung ist zu ersehen, dass der Kopfteil unserer Exemplare genau denselben Bau hat, wie bei dem von Levinsen beschriebenen Exemplar.

Alle Borstensegmente, auch das erste (2. Körpersegment) und das Analsegment, sind mit dorsalen und ventralen Cirren und dorsalen und ventralen Podialhöckern versehen. Dorsale Cirren sind sehr gross und lang, ihre Enden überragen die Dorsalborsten. Sie haben einen länglichen Cirrophorus und einen länglichovalen Cirrostylus. Ventrale Cirren kurz, kegelförmig, mit sehr niedrigem Basalglied. Dorsalborsten von dunkelbrauner Farbe, dünn und schwach gebogen, quer gestrichelt mit gezahntem Rand. Im Podialhöcker sind sie, nicht fächerförmig, wie das bei anderen *Chrysopetalidae* beobachtet werden kann, sondern büschelförmig angeordnet. Ihrer Form und Farbe nach erinnern diese Borsten eher an die Dorsalborsten der *Aphroditiden* als der *Chrysopetaliden*. Ventralborsten zusammengesetzt, mit verlängertem Endglied, das eine gebogene, einzähnige Spitze hat. Analsegment mit einer grossen Analpapille versehen, die eine breite Basis und eine kurze fingerförmige Spitze hat; diese Papille bedeckt die Analöffnung von der Dorsalseite.

Die Form der deutlich durch die Körperwandung durchscheinenden Kieferplatten ist bei unseren Exemplaren dieselbe wie bei dem von Levinsen beschriebenen Exemplar.

Der *Dysponetus pygmaeus* lebt in geringen Tiefen des Sublitorals (0—50 m), zwischen Dickichten von *Amphiroa*, *Ljthothamnia*, an der Unterseite der Steine in sublitoralen Pfützen und kommt selten zwischen Corallinen, d. h. in der Litoralzone vor. Levinsen gibt an, dass die Art zwischen den Rhizoiden von Laminarien vorkommt. Im allgemeinen kann gesagt werden, dass diese Art in verschiedenen pflanzlichen Biocönosen der Uferzone vorkommt, die Felsen und Steinen eigentümlich sind. Nach den uns vorliegenden Angaben gehört die Art hauptsächlich dem *Amphiroa*-Horizont an. An sandigen Ufern ist der *Dysponetus pygmaeus* von uns nicht festgestellt, trotzdem Webster und Benedict angeben, dass der *Taphus hebes* von ihnen in sandigem Grund gefunden worden ist, wobei allerdings bemerkt wird, dass es eine sehr seltene Art sei. Doch lässt sich wohl ebenso gut annehmen, dass einzelne Vertreter dieser Art in sandigen Grund zufällig geraten könnten.

Vergleichende Bemerkungen. Augener (2) sieht den *Taphus hebes* als Synonym von *Dysponetus pygmaeus* an. Ich teile durchaus seine Ansicht, bin aber etwas anderer Meinung hinsichtlich der Bedeutung einiger Anhänge des Kopfes, die von Webster und Benedict beschrieben und

abgebildet werden. So sehen wir auf der Abbildung des Kopfteiles von *Taphus hebes* in der Dorsalansicht drei Antennen, zwei zur Seite geschobene Palpen, während die Tentakelcirren, die bei der vorliegenden Art etwas hinter den paarigen Antennen liegen müssen, auf der Zeichnung fehlen. Die Abbildung des Kopfteiles von der Ventralseite ist sehr schematisch, aber man sieht immerhin zwei Antennen, zwei dicke massive Palpen und zwei kegelförmige kurze Papillen, von denen die Autoren schreiben: «Just back of the palpi, on the anterior margin of the first segment, is a pair of conical cirri; their function or homology we do not understand» (p. 716). Augener betrachtet diese kegelförmigen Papillen als Tentakelcirren des Buccalsegments, und nicht als Anhänge des Mundapparats. Ich glaube dagegen dass in der Beschreibung und auf den Abbildungen des Kopfteiles von *Taphus hebes* gerade die Tentakelcirren fehlen, während die konischen Papillen Mundanhänge darstellen, die bei allen unseren Exemplaren deutlich bemerkbar sind und auch von Levinsen erwähnt werden. Bei dieser Interpretation der Kopfanhänge von *Taphus hebes* können wir behaupten, dass diese Art mit dem *Dysponetus pygmaeus* identisch ist und sich nur durch das Vorhandensein von zwei sehr kleinen Augen unterscheidet.

Ich nehme also an, dass bei *Dysponetus* und bei *Taphus* 3 Antennen vorhanden sind, 1 Paar Palpen, 1 Paar Tentakelcirren, die bei *Taphus* nicht angegeben sind, und 1 Paar Mundpapillen. Augener nimmt dagegen 3 Antennen, 1 Paar Palpen und 2 Paar Tentakelfühler an, indem er die Mundanhänge als zweites Tentakelcirrenpaar ansieht. Aus diesem Grunde schliesst er auch noch das *Chrysopetalum caecum* L a n g e r h a n s dem *Dysponetus pygmaeus* an. Aber selbst wenn wir die Mundanhänge als ventrale Fühler des Buccalsegments ansehen, können diese zwei Arten nicht vereinigt werden und zwar aus folgenden Gründen: 1) Das *Chrysopetalum caecum* besitzt 2 Tentakelfühler, ebenso wie bei allen Vertretern der Gattung *Chrysopetalum*, und diese Fühler sind normal entwickelt, lang, länger als der Kopflappen; 2) das ventrale Paar dieser Fühler ist nicht rudimentär und nicht auf die Ventralseite verschoben. Mir scheint, dass diese Unterschiede zur Genüge darauf hinweisen, dass *Chrysopetalum caecum* nicht Synonym von *Dysponetus pygmaeus* ist. Nach dem Bau des Kopflappens und der zwei ersten Segmente muss diese Art zur Gattung *Chrysopetalum* gehören, während nur die feinen Dorsalborsten und die Form des Analsegments sie der Gattung *Dysponetus* näher bringen.

Euzonus arcticus G r u b e (1866)

Ophelia (Euzonus) sp. Zachs 1933 ([13])

Ein Exemplar dieser Art wurde von mir in grobkörnigem Sandboden auf einer Tiefe von 20—25 cm an der Linie der Ebbe in der Bucht Quandagou des Meerbusens Sjauchu erbeutet.

Es existieren zwei Beschreibungen von *Euzonus arcticus*, die auf Grund ein und desselben Materials abgefasst sind, nämlich die kurze Beschreibung von Grube ([6,7]) und die ausführlichere von Augener ([3]). Aus diesen Beschreibungen, sowie aus den Zeichnungen, die Augener gibt, ist deutlich zu ersehen, dass der Körper von *Euzonus arcticus* aus 3 Partien besteht: dem Kopfteil, der vom zweiten, dem Thoracalteil (Augener, T. V, Abb. 12), welcher von den angegebenen Autoren wegen des schlechten Erhaltungszustandes des Materials nicht genau beschrieben wird, scharf abgegrenzt ist, und dem dritten, dem Abdominalteil, der mit verästelten Kiemen versehen ist. Diese Art hat also alle Gattungsmerkmale, die der Gattung *Thora-*

cophelia Ehlers eigentümlich sind, ausgenommen die seitlichen Thoracalfalten, die bei der Beschreibung wahrscheinlich ebenfalls wegen des schlechten Erhaltungszustandes des Materials übersehen wurden. Offenbar müssen die Gattungen *Euzonus* und *Thoracophelia* vereinigt werden, wobei als Gattungsname *Euzonus* bestehen bleibt, da die Beschreibung Grubes Prioritätsrechte hat.

Nach der Form des Körpers und dem Bau seiner drei Partien gleicht das im Japanischen Meer erbeutete Exemplar ganz der *Thoracophelia furcifera* Ehlers und *Th. yasudai* Okuda. Es besteht aus 39 Borstensegmenten und hat eine Länge von 2 mm; die Breite der Thoracalpartie beträgt 4 mm der Abdominalpartie 3 mm. Die Ventralfurche beginnt am 10. Borstensegment. Der Kopflappen und die zwei ersten Borstensegmente bilden zusammen den ersten Körperteil, d. h. den Kopfteil. Die nachfolgenden 8 Borstensegmente bilden den Thoracalteil, wobei das letzte Segment dieses Teiles (10. Borstensegment) zwei dicke seitliche Drüsenfalten aufweist. Der Abdominalteil besteht aus 29 Borstensegmenten. 17 Kiemenpaare beginnen am 13. Borstensegment (3. Abdominalsegment), die letzten 10 Segmente sind kiemenlos. Alle Kiemen sind verästelt; ihr Hauptstamm ist aufwärts zur Dorsalseite gerichtet; von diesem Stamm gehen 3—7 in einer Ebene angeordnete rückwärts gerichtete Äste ab. Während der untere erste Ast nicht verästelt ist, sind die übrigen zweimal dichotomisch verästelt. Alle Borstensegmente mit Ausnahme der 5 letzten tragen kurze, sehr dünne Borsten. Die letzten 5 Segmente sind mit sehr langen haarförmigen Borsten versehen, welche die Abdominalpapillen verdecken. Das (5.) Endglied bildet eine breite Falte um die nachfolgenden 4 Segmente, dieselben auf der Ventralseite fast ganz bedeckend. Analöffnung von 3 Lappen umgeben: einem sehr grossen ventralen Lappen mit breiter Basis und zwei Seitenlappen, die mit 6—9 langen Papillen versehen sind.

Ich halte unser Exemplar für einen *Euzonus arcticus*, weil es keine Augen hat und mit 17 Kiemenpaaren sowie 18 seitlichen Analpapillen ausgestattet ist.

Die *Thoracophelia furcifera* Ehlers unterscheidet sich vom *Euzonus arcticus* durch das Vorhandensein von Augenflecken, grössere Kiemenzahl (20 Paare) und geringere Zahl der seitlichen Analpapillen (10). Die *Thoracophelia yasadai* Okuda underscheidet sich vom *Euzonus arcticus* nur durch das Vorhandensein von Augenflecken und 15 Kiemenpaaren. Die Zahl der seitlichen Analpapillen ist bei diesen Arten die gleiche.

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ZOOLOGIE

ÜBER DAS AUFTRETEN VON *ACARTIA TONSA* Dana (*COPEPODA*) IM FINNISCHEN MEERBUSEN

Von S. S. SMIRNOV

(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d. 3. VII. 1935)

Vor kurzem übergab mir A. A. Wulfius, der z. Z. von der letzten Expedition des Forschungsinstituts für See- und Flussfischerei die aufgebrachten Planktonsammlungen aus dem Finnischen Meerbusen bearbeitet, ein Acartia-Weibchen zur Bestimmung. Schon vom ersten Anblick ersah ich, dass das betreffende Weibchen keiner bisher aus der Ostsee bekannten Acartia-Art angehören kann und der *Acartja tonsa* Dana am nächsten steht. Die eingehendere Untersuchung dieses Exemplars hat meine provisorische Bestimmung vollkommen bestätigt. Das mir zur Bestimmung vorgelegte Exemplar war in einer Probe entdeckt, welche am 30. VI. 1934 mit Petersen'schem Bodenschöpfer in der Luga-Bucht des Finnischen Meerbusens (St. XXVI, S‰ 2.65) gesammelt wurde. Trotz sorgfältiger Durchmusterung anderer von derselben Expedition mitgebrachten Proben hat man *Acartia tonsa* in keiner weiteren Probe entdeckt. Immerhin ist jede Möglichkeit einer Verschleppung des betreffenden Exemplars mit den Fangapparaten vollkommen ausgeschlossen. So dürfen wir der Ostsee-Fauna noch eine Tierart einfügen und dabei eine Art, deren Vorkommen im Finnischen Meerbusen durchaus unerwartet war.

Die betreffende Acartia-Art wurde von Dana (2) aufgestellt und später von Giesbrecht (5) in seiner wohlbekannten Monographie der pelagischen Copepoden ausführlicher beschrieben. Beschreibungen von *Acartia tonsa* findet man auch ferner noch bei einigen anderen Autoren [Esterly (4) u. a.].

Schliesslich hat Remy (10) eine erschöpfende Beschreibung von *Acartia tonsa* gegeben und halte ich es für überflüssig, diese Form nochmals zu beschreiben. Ich möchte nur bemerken, dass die im Finnischen Meerbusen gefangene *A. tonsa* in allen wesentlichen Merkmalen mit den Angaben Remy's besser als mit solchen von Giesbrecht übereinstimmt. Der innere Vorsprung des 2. Basalgliedes des 5. Fusses ist viel stärker ausgeprägt als es in der Fig. 24, Taf. 30 bei Giesbrecht zu sehen ist. Der Exopodit desselben Fusses ist auf der Abbildung Remy's viel ähnlicher.

Das auffallendste Merkmal der *A. tonsa* welches uns erlaubt, diese Art von den anderen in der Ostsee vorkommenden Acartia-Artent leicht zu unterscheiden, ist die Bewehrung des Exopoditen des rudimentären weiblichen Füsschens, der an beiden Rändern je eine Reihe von gut wahrnehmbaren ziemlich breiten Zähnchen besitzt (die Zahl dieser Zähnchen betrug bei dem von mir untersuchten Exemplar je 7 in jeder Reihe). Gleich hinter den Zähnchenreihen weist der Exopodit des Füsschens eine starke Verengung auf, während er im proximalen Abschnitt ziemlich dick und an der Basis merklich angeschwollen ist. Ein anderes charakteristisches Merkmal der betreffenden Art ist das Vorhandensein eines gut ausgebildeten Vorsprunges am 2. Basalgliede des rudimentären Fusses. Der Vorsprung ist unzweifelhaft als ein Endopoditenrudiment zu betrachten, worauf schon Esterly [(4), p. 107] hinwies, indem er schrieb: «This process looks something as an inner ramus». Es ist auch zu bemerken, dass das Vorhandensein eines rudimentären Endopoditen beim 5. weiblichen Fusse noch in einer anderen Acartia-Gruppe beobachtet wurde und zwar bei *A. bermudensis* Esterly, welche zur Steuer'schen Gruppe *Acartiae arostratae* gehört. Der Exopodit des rudimentären weiblichen Fusses bei dieser letztgenannten Art ähnelt recht nahe dem entsprechenden Fussteil von *A. tonsa*. Es ist möglich, dass wir in *A. tonsa* und *A. bermudensis* zwei paralelle Formen, zwei entsprechende Glieder zweier homologen Entwicklungsreihen vor uns haben. Das Vorhandensein eines rudimentären Endopoditen weist auf relative Primitivität dieser Formen hin. Es wäre höchst interessant in dieser Gattung auch die anderen Merkmale zu verfolgen, welche zur Feststellung des relativen Spezialisationsgrades dienen könnten.

Die von Dahl nach dem Material aus der Amazonas-Mündung (Rio Tocantins) aufgestellte *Acartia giesbrechti* [(1) 1894, p. 22, Taf. I, Fig. 15—18] steht, wie es auch der Autor selbst betont, der *A. tonsa* Dana recht nahe. Dahl hält, dass die von ihm entdeckte *Acartia* durch folgende Merkmale von *A. tonsa* sich unterscheidet. Weibchen von *A. giesbrechti* haben an der Dorsaloberfläche der Abdominalsegmente je eine Reihe von feinen Zähnchen (fehlen auf der Abbildung von Giesbrecht) und «an den Seiten des Analsegmentes sind höchstens vereinzelte Härchen sichtbar», während Giesbrecht das Analsegment seitlich dicht behaart abbildet. Ausserdem hebt Dahl noch einige geringe Abweichungen im Bau des 5. Fusspaares bei beiden Geschlechtern hervor, wobei er auf seine Abbildungen verweist ohne im Text weiter darauf einzugehen. Ein anderer Forscher, welcher mit *A. giesbrechti* sich befasste, A. Scott, sieht diese Form als eine selbständige, von *A. tonsa* verschiedene Art an. Seiner Meinung nach [(11) p. 50] «in the female of *A. tonsa* each foot of the fifth pair ends in a spine, but in the female of *A. giesbrechti* each foot of the fifth pair ends in a slender seta». In derselben Arbeit werden einige sorgfältig ausgeführte «Abbildungen von *A. giesbrechti* gegeben. Steuer in seiner Übersicht der Gattung *Acartia* (13) schreibt über *A. tonsa*: «Abdomen des ♀ kurz, nackt, nur *Ab* 5 beiderseits behaart», während bei *A. giesbrechti*

die Hinterränder von *Ab* 1—3 und *Ab* 4* mit Zähnchenreihen versehen sind. Wenn wir weiter zu anderen Beschreibungen der *A. tonsa* von Esterly [4] und Remy [10] uns wenden, so finden wir, dass alle Merkmale, welche von Dahl einer Abtrennung der *A. giesbrechti* von *A. tonsa* zugrundegelegt wurden, eine beträchtliche Variation aufweisen und in verschiedenen Kombinationen vorkommen, so dass es nach meinem Dafürhalten gewagt wäre, die spezifische Selbständigkeit der *A. giesbrechti* darauf zu begründen. Wegen Mangel an Material habe ich keine Möglichkeit über die artliche Selbstständigkeit von *A. giesbrechti* mich kategorisch zu äussern, doch glaube ich, dass die Zugehörigkeit beider betreffenden Formen zu einer und derselben Art äusserst wahrscheinlich ist. Es sei noch bemerkt, dass in einer kürzlich erschienenen Arbeit Redeke [[8] p. 315, Anm.], indem er die europäische *Acartia tonsa* behandelt, die Vermutung ausspricht, dass *A. tonsa* aus Europa eine besondere Art darstelle. Die Abwesenheit der typischen *A. tonsa* in den mir zur Verfügung stehenden Kollektionen erlaubt mir nicht, auf diese Frage einzugehen.

Es scheint mir überflüssig, hier eine ausführliche Zusammenstellung der vorhandenen Angaben über die Verbreitung von *Acartia tonsa* zu machen, da eine solche in der oben zitierten Atbeit von Remy bereits gegeben ist. *Acartia tonsa* ist eine typische Küstenplanktonform und längs der pazifischen Küste Amerikas weit verbreitet, nördlich bis San Francisko vorstossend. Sie wurde auch an der Ostküste Australiens, im Malayischen Archipel und im Indischen Ozean angetroffen, längs der Atlantischen Amerika-Küste von Fundy Bay bis Louisiana, nahe der Orinoko-Mündung und weiter bei den Falkland-Inseln. In 1927 hat Remy diese Art aus Europa (Umgegend von Caen im Frankreich) zum ersten Mal angemeldet und eine vortreffliche Übersicht der bisherigen Kenntnisse über *A. tonsa* gegeben. Nach dem Erscheinen der Arbeit Remy's wurden noch Angaben von Klie über das Vorkommen dieser Art in der Weser-Mündung und im Ryngköbing-Fjord (westliche Küste Jütlands) und in der Kieler Bucht [6,9] veröffentlicht. Es ist interessant hervorzuheben, dass *Acartia tonsa* im Ryngköbing-Fjord schon im Jahre 1921 gesammelt wurde, d. h. früher als sie von Remy in der Umgegend von Caen bemerkt war. Von grossem Interesse sind die Arbeiten von Redeke [7,8] der nach Bearbeitung der im Laute der Jahre 1905—1933 in Holland gesammelten Planktonmaterialien zum Schlusse kommt, dass *A. tonsa* im Holland zwischen 1912 und 1916 erschien und allmählich eine immer grössere Rolle im Plankton an sich riss, indem sie (wenigstens in den Sommermonaten) die ökologisch äusserst nahe stehende *A. bifilosa* G s b r. zurückdrängte. Man kann nun mehr eine vom zoogeographischen Standpunkt auch recht interessante Tatsache für festgestellt halten, nämlich dass die *A. tonsa* relativ nur recht kürzlich in Europa auftauchte und dass sie augen-

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* Ich verwende hier die von Steuer [12,13] eingeführten Bezeichnungen der Abdominalsegmente.

scheinlich in aktiver Weise längs der europäischen Küsten sich verbreitet, wobei ihre ungemein starke Anpassungsfähigkeit an verschiedene Salz- und Temperaturverhälthisse diesem Vorgang in hohem Masse förderlich ist. Erinnern wir nur an die von Wilson angeführte Tatsache, dass *A. tonsa* sowohl im normalen Meerwasser als auch in vollkommen süssen Seen leben kann. Was nun die Einwanderungswege dieser Art in Europa anbetrifft, so glaubt Redeke, dass *A. tonsa* in europäische Gewässer von Nordamerika aus eingewandert und wohl durch den Ärmel-Kanal in Holland eingedrungen sein dürfte. Es ist zu vermuten, dass das Erscheinen von *A. tonsa* im Finnischen Meerbusen auf die ganz jüngste Zeit sich bezieht. Zwar darf man den Grad der Erforschung der Ostsee-Copepodenfauna nicht allzu hoch einschätzen, wir können aber mit Rücksicht auf die schon hervorgehobene Abwesenheit dieser Art bis zur jüngsten Zeit in Westeuropa mit einer gewissen Wahrscheinlichkeit annehmen, dass die Einwanderung der *A. tonsa* in den Finnischen Meerbusen vor unseren Augen vor sich geht; ja, es ist sogar möglich, dass wir tatsächlich gerade diesen Zeitpunkt erfasst haben.

Es wäre recht erwünscht, in demselben Gebiet auch weitere Untersuchungen vorzunehmen, die uns erlaubten das Schicksal der betreffenden Art im Finnischen Meerbusen zu verfolgen.

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